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Dealer Jerry Romanella's Collection of Unknowns

par
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Before the following jury

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Introduction:

For the research project the author needed a collection of gemstones to experiment with and research. The author did not have a collection nor a collector. So did the next best thing, find a collector.

What made this interesting was it simulated what the experience is working in a real life laboratory. Instead of just focusing on one stone, it allowed for recreating what it would be like working in a laboratory. As it is what the author would like to do, this was the closest way to create that feeling.

The author requested from the well known, colored stone dealer Jerry Romanella, a parcel of stones that they would like lab work done on, but the value was too low to send to a lab. Seventeen stones were provided. Only a few of the stones had labels. All the stones were difficult to identify using classic gemology and easy using advanced techniques. The results for many of the stones were surprising.

The collection of gemstones is owned by Jerry Romanella, a well known colored stone dealer in Scottsdale Arizona. He and his brother Michael operate the company Commercial Mineral Company. The company was founded by their father, Ron Romanella, in 1952. They trade in a wide array of colored stones. Commercial Mineral Co. is the exclusive marketer and distributor of Four Peaks amethyst. The mine is owned by Kurt Cavano and Jim MacLachlin. The mine is located east of Fountain Hills in the Four Peaks Mountains.

By testing a random selection of gemstones and without any prior information, an analog of a gemstone laboratory was produced. Beyond classic gemology testing, as many tests were conducted as available. Most of the tests were unnecessary as the gemstone identity was confirmed conclusively but acted as additional practice with the advanced equipment and procedures.

The few stones that had labels were frequently of different identity. By taking on the parcel blind, preexisting bias was avoided. The advanced test data were collected before the classic gemology data. The test data led the determination not preconceived notions.

The largely eclectic species of gemstones were in a wide range. Stones that are considered common in the industry as well as very unusual were present in the parcel. The parcel had natural, untreated stones through to treated synthetic stones.

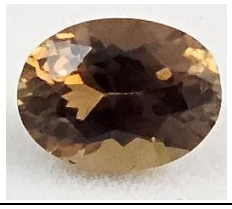
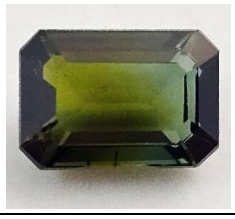
In general, having just one advanced test in addition to the classic tests (see table 2) would be enough to positively identify almost all of the stones with a high degree of certainty. All the samples studied are described in table 1. It would not be unreasonable to determine that the author was just having fun with the journey.

Materials and Methods:

Stones were tested using advanced methods before classical gemological techniques to not have preconceived bias. As many different techniques were used to maximize the opportunity of gaining experience as possible. When time permitted tests were redone with improved understanding of procedures and settings to collect higher quality data.

Table of Samples (table 1):

Number	Mass(ct.)	Dimensions (Length, Width, Depth in mm.)	Shape/Cut	Photo
1	0.571	6.00, 6.14, 2.92	Cabochon Triangle	
2	18.311	21.77, 15.29, 7.92	Cabochon Lozenge	
3	5.414	13.90, 9.98, 6.76	Faceted Oval	
4	0.353	6.12, 4.13, 2.93	Faceted Oval	
5	2.188	11.55, 7.15, 4.47	Faceted Pear	

6	2.038	7.57, 7.56, 4.84	Faceted Cushion	
7	2.183	9.97, 7.74, 2.86	Faceted Oval	
8	0.763	6.82, 5.09, 2.86	Faceted Oval	
9	2.826	Avg. Diameter 8.85, D 4.61	Faceted Round	
10	2.870	10.10, 8.01, 4.41	Cabochon Oval	
11	3.021	10.18, 7.08, 4.63	Faceted Cut-Cornered Rectangle	
12	1.966	8.64, 6.50, 3.86	Faceted Oval	
13	0.961	7.24, 5.47, 3.70	Faceted Oval	

14	0.639	5.56, 4.54, 2.95	Faceted Cut-Cornered Rectangle	
15	1.231	8.13, 6.04, 3.30	Faceted Oval	
16	2.780	Avg. Diameter 8.05, Depth 5.15	RBC	
17	1.791	Avg. Diameter 7.05, Depth 4.33	RBC	

Table 1: RBC-Round Brilliant Cut.

Table of Gemological Properties (Table 2):

Number	RI	Birefringence	Optic Figure	SG	UV Short Wave	UV Long Wave
1	1.39 Spot	-	AGG	2.278	Weak White	Strong Pink
2	1.62 Spot	-	DR	3.131	Inert	Inert
3	1.54-1.55	0.01	AGG	2.652	Inert	Inert
4	1.503-1.514	0.011	DR	2.890	Weak White	Weak Yellow
5	1.657-1.667	0.01	DR	2.187	Inert	Weak Orange
6	1.712-1.719	0.007	DR	2.038	Inert	Inert
7	1.763-1.771	0.008	DR, Uniaxial	4.018	Inert	Inert
8	1.622-1.638	0.016	DR	3.083	Moderate Yellow	Inert
9	1.762-1.771	0.009	DR, Uniaxial	2.826	Inert	Inert

10	1.51 Spot	-	AGG	2.840	Inert	Strong Green
11	1.622-1.641	0.019	DR, Uniaxial	3.065	Inert	Inert
12	Before Repolish: 1.740-1.743 After Repolish: 1.763-1.770	Before Repolish: 0.003 After Repolish: 0.007	DR, Uniaxial	3.981	Weak White	Inert
13	1.6	0.02	DR	3.191	Strong Yellow	Moderate Orange
14	1.648-1.670	0.022	DR	3.182	Strong Orange	Weak Orange
15	1.713-1.718	0.005	AGG	3.358	Inert	Inert
16	OTL	-	SR	4.566	Weak Yellow	Moderate White
17	OTL	-	SR	4.542	Inert	Inert

Table 2: Abbreviations; RI- Refractive Index, OTL- Over the Limit (above 1.80), SG-Specific Gravity, UV-Ultraviolet, AGG-Aggregate, DR-Doubly Refractive, SR-Singly Refractive. See images 1-3 for daylight and long and short wave UV reactions

Image 1-3: All of the 17 gemstones tested under different lighting conditions; (Image 1) Top: daylight, (Image 2) Middle: long wave UV, (Image 3) Bottom: short wave UV

Equipment:

Below are the general settings used for experimentation. If alternative settings were used, they are noted in entries. Additional test settings are listed at end of paper for experiments that were not listed in the paper.

Raman

Raman T64000

Micro-Raman scattering spectra were measured with an argon excitation laser at 514.5-nm, using a T64000 Horiba Jobin-Yvon spectrometer equipped with a microscope (objective at 50x) in backscattering configuration. The spectra were acquired between 200 and 1200 cm^{-1}. The number and time of scans varies.

Raman (Renishaw)

Raman spectra were obtained on a Renishaw InVia confocal Raman microscope fitted (with a 50 objective) with a 514 nm laser excitation (with a power of 10), with a grating of 2400 grooves/mm. Spectra were acquired in the range 100-1400 cm^{-1}, with a resolution of 0.5 cm^{-1} and over an accumulation of 20 scans.

Raman on Labram Hrevo

Raman spectra were obtained on a Labram Hrevo Raman fitted with a 532 nm laser excitation with a power of 125 mW, spectra were acquired in the range of 100-1000 cm^{-1}, with 5 scans for 5 seconds each.

UV-Visible spectrometers

Gemmosphere

Ultraviolet-visible-near infrared (UV-vis-NIR) absorption spectra in the range of 300-1000 nm were recorded for all samples with a MagiLABS GemmoSphere (equipped with an integrating sphere) in transmitted light, with an average accumulation of 100 scans and a resolution of 1 nm.

Infrared

Brucker Vertex

The equipment used was a Brucker Vertex 70 FTIR Spectrometer, with a CaF_2 beam splitter and a MIR light-source. The FTIR spectra was recorded in the 1800-5500 cm^{-1} range with 1000 scans and 4 cm^{-1} spectral resolution in transmission/reflection mode.

SEM

IT510

Scanning electron microscope JEOL JSM IT510 working at 15KV for a beam current in the 1nA range, providing sufficient statistics for the acquisition of spectra and maps by the integrated EDS detector. Images are acquired using either an Everhart-Thornley secondary electron detector or a dual PN junction backscattered electron detector.

Standard Gemology Equipment

Gemological Institute of America (GIA) standard gemology equipment used; refractometer, polariscope, and dichroscope. The GIA refractometer Duplex II is the better all around (compared to the GEM-A and Japanese) refractometer and measures have a larger visible range does spot RI measurements very well.

Gemmological Association of all Japan (JAAJ) Topcon refractometer used at the IMN for additional confirmation. This style refractometer is very good at high RI readings, but not good for low readings or spot RI.

Gemmological Association of Great Britan (Gem-A) KASSOY refractometer used at the IMN for additional confirmation. This style refractometer is very good at low RI readings, but not good for high readings or spot RI.

Mettler Toledo Excellence scale used at the IMN for all weight measurements. The measurements taken were carat weight and specific gravity.

Custom Meiji gemological microscope was used for examination with magnification and photomicroscopy. The microscope can magnify up to 70x (standard gemological microscopes can only magnify to 60x) and has well and overhead integrated lighting. Pictures were taken through one of the eye pieces.

UV light bar with 365nm and 254nm lights at the IMN was used for the UV reaction images and observations used in this report. The large size facilitated all 17 stones to be observed at once.

Sample #01

Gemstone	Hackmanite (Sodalite)
Sample Name	SPM-JRUS-1
Weight (ct.)	0.571
Color	Light Purple to Dark Purple
Shape/Cut	Cabochon Triangle
Length (mm)	6.00
Width (mm)	6.14
Depth (mm)	2.92
Mass Volume (g/cm^3)	2.278

Classic Gemology:

Refractive Index	1.39 spot
Birefringence	-
Optic Figure	AGG
UV Shortwave	Weak White
UV Longwave	Strong Pink
Phenomenon	Tenebrescence

The light purple gemstone is a cabochon at first look has some feathers and a grainy appearance. Without doing any tests and just sight identifying, rose quartz would be a reasonable guess. The spot refractive index (RI) is 1.39. The stone does not have a flat facet, and all surfaces are convex. It was difficult to get a good reading. Using the polariscope, under crossed polarizing filters, the stone stayed light during rotation, so had an aggregate (AGG) reading. GIA Lab Manual does not list hackmanite or sodalite, so using it would mislead the reader into choosing calcite, fluorite or glass and plastic. Using GIA's standard minimalist gemology approach would lead to confusion. The polariscope and refractometer are not enough to determine the identity of this stone.

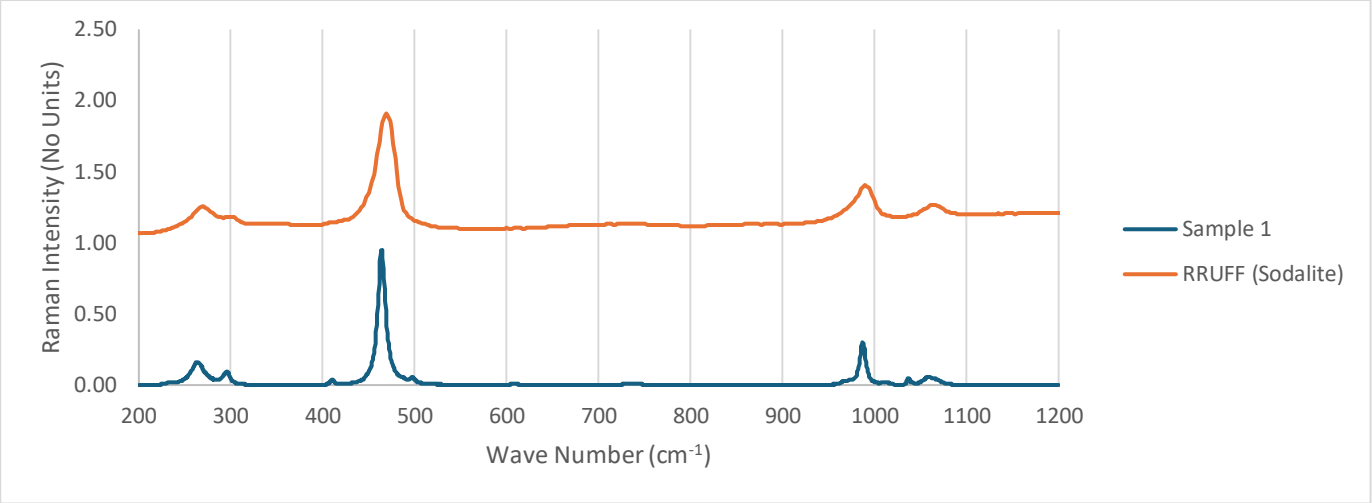
But if additional classical gemology tests are conducted and the user is knowledgeable the GIA resources can be useful. If a UV torch is used then the identification process would be streamlined, as

the stone has an unusual UV activated characteristic. The stone changes from a light purple to a dark purple (see image 4 and 5) and seems to stay that color, at least for the short term, so it is tenebrescent! There are not many stones that are tenebrescent and even fewer that are purple. The GIA Reference Guide lists sodalite, and hackmanite under variety but only describes a pink that rapidly fades. A good confirmation test would be the specific gravity. The stone had a 2.278 specific gravity, which is very close to the listed 2.25 (+.15, -.10). The spot RI is 1.39, but the listed is 1.483 (+/-.004), which is not close, but might be a result of the inaccurate nature of spot reading. The AGG optic character, close SG and UV reaction make hackmanite a reasonable conclusion. This stone can be identified with classic gemology but not using the basic tests or resources and is only possible through knowledge of unusual UV reactions.

Image 4: Hackmanite before UV exposure

Image 5: Hackmanite after UV exposure

Advanced Gemology:



Graph 1: match. Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 12 scans of 10 seconds. Using RRUFF database R040141 Sodalite from Princess Sodalite Mine, Bancroft, Ontario, Canada, had an 99% match

Advanced testing was also imperfect but was related to the depth and quality of the reference library. The MAGI database/library did not have hackmanite or sodalite. The MAGI database had an 85% match with sample ABS00157, a dyed and impregnated lavender jade. If the user only relied on the Gemmosphere and the MAGI database and not any classic gemology, they would have the wrong conclusion.

The Raman T64000 spectra was compared to using the RRUFF database sample R040141 Sodalite from Princess Sodalite Mine, Bancroft, Ontario, Canada, and had an 99% match (See graph 1). The peaks match and the database have several samples that also match well.

The spectra had distinct peaks at 263cm^{-1}, 465cm^{-1}, 987cm^{-1}. The 263cm^{-1} is assigned to framework and $[ClNa_4]^{3+}$ cluster bending models. The 465cm^{-1} peak is due to symmetric T-O-T bending and $[ClNa_4]^{3+}$ cluster stretching. The 987cm^{-1} peak is symmetric v_1 (T-O) and asymmetric v_{as}(T-O-T) stretching (Apopei & Astefanei, 2025).

Conclusive Remarks

The classic and advanced gemology, with tenebrescence supports the hackmanite determination. The gem was originally labeled hackmanite from Mogok (Myanmar). While the RRUFF database lacked any samples from Mogok to compare too, the samples from Afghanistan, Bolivia and Canada, matched the species very well. The Hackmanite had good tenebrescence that slowly transitioned back over several days with indoor lighting after exposure to shortwave UV. Getting the right answer to the identity of the stone would be difficult if just going off results and not having a knowledge of gemology even with advanced testing.

Sodalite with color change was first described by Robert Allan in correspondence with his father and Karl Giesecke in 1806. He wrote that the color disappeared after sun exposure. The hackmanite's purple color would return with exposure to short wave UV. Hackmanite was named after Victor Hackman, who gave Leon Borgstrom a Russian sample in 1901. The sulphur component of the structure is believed to be linked to the photochromism. The structure has chains with "cages", and if sulphur ions are substituted in the trap instead of chlorine, the color change can occur (Blumentritt & Fritsch, 2021). Hackmanites pink color is due to the color centers related to chlorine (Gemological Institute of America, 1995). The S that substitutes for the Cl creates a Cl vacancy. But the Cl vacancy makes the Sulfur ion unstable, and decomposes easily with UV light, turning the stone purple temporarily (Song et al., 2023).

Sample #02

Gemstone	Lazulite
Sample Name	SPM-JRUS-2
Weight (ct.)	17.311
Color	Dark Blue with Greenish Yellow Zoning
Shape/Cut	Cabochon Lozenge
Length (mm)	21.77
Width (mm)	15.29
Depth (mm)	7.92
Mass Volume (g/cm^3)	3.131

Classic Gemology:

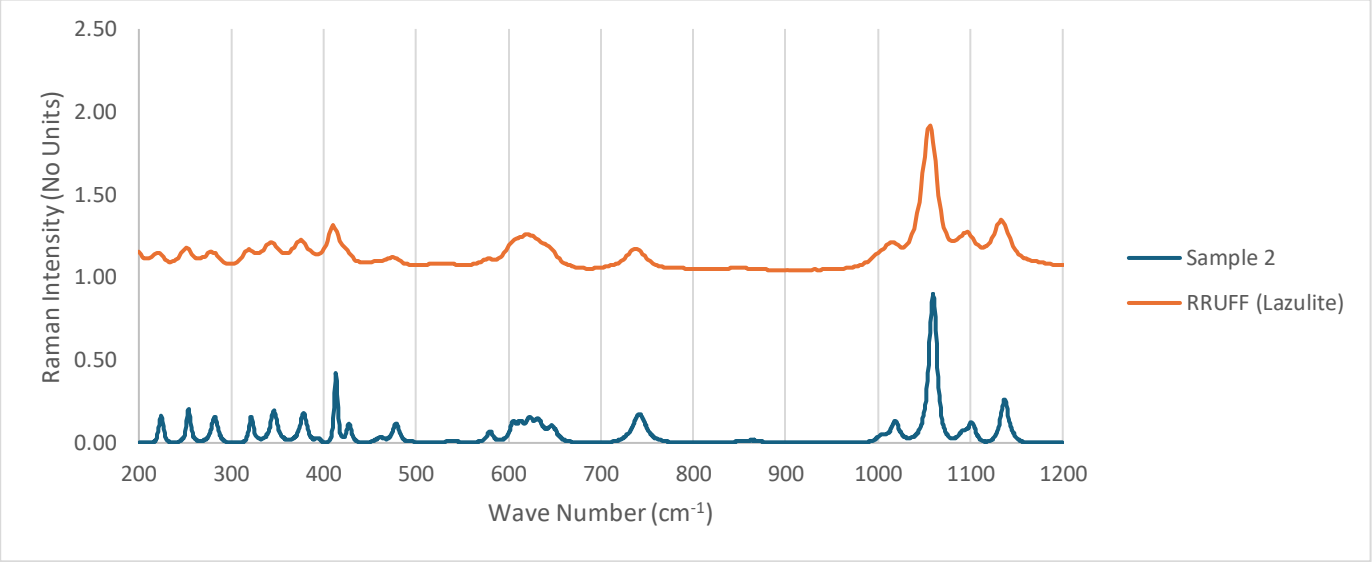
Refractive Index	1.62 spot
Birefringence	-
Optic Figure	DR
UV Shortwave	Inert
UV Longwave	Inert

The lozenge shaped cabochon that was tested was transparent and had a dark blue color. But under strong lighting the stone revealed color zoning at one end of the stone. Without testing, the stone had the appearance of a dark inky greenish blue Australian sapphire. The gemstone has a spot refractive index of 1.62 and doubly refractive (DR), way too low for sapphire, but in range apatite, tourmaline, and lazulite. Using the dichroscope was dark blue and a light blue. The stone was inert for fluorescence, which eliminates apatite. The SG was 3.131, which is in range of tourmaline and lazulite. Magnification provided the information to make the separation.

Most of the stone was deep blue and the minor area a greenish yellow. The delineation was striking, and even more so under crossed polarizers (see image 6). This can be best explained as twinning. Under magnification and lighting, cleavage planes can also be observed in relation to the twinning plane. This best supports lazulite.

Image 6: Twinning visible under crossed polarizers.

Advanced Gemology:



Graph 2: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 12 scans of 10 seconds. Spectra comparison with RRUFF R050110 Lazulite from Rapid Creek, Yukon Territory, Canada and very close matches with samples from Sweden and the US.

Advanced testing made determination very easy. The T64000 Raman had a 95% match with RRUFF R050110 (see graph 2) Lazulite. The peaks matched and that supported by classic gemology made for high confidence of the stone's identity.

The major peak in the collected spectra is 1060cm^{-1}. This is attributed to PO stretching vibration HPO^{2}_{4}-units. The next main band is 414cm^{-1} and attributed to the m2 tetrahedral PO4 clusters, HPO 4 and H2PO 4 bending modes. Other significant peaks include 1102cm^{-1} and 1137cm^{-1} are related to HOP & PO antisymmetric stretching vibrations (Frost et al., 2013).

Conclusive Remarks

Lazulite is an uncommon gemstone and is not widely used in jewelry. Though it is very attractive, it is not very hard (5-6 Mohs) and has poor toughness. The material has strong pleochroism. The blue color is due to iron (Gemological Institute of America, 1995). The blue color resembles lapis lazuli. The material can show colorless to light blue and dark violet-blue in dichroism (Liddicoat, 1988). The stone is often twinned on the (100) plane. The mineral can have good cleavage along the (110) plane. The mineral forms when quartzose rocks have high Al (Bernard & Jaroslav, 2015).

Sample #03

Gemstone	Quartz with Actinolite
Sample Name	SPM-JRUS-03
Weight (ct.)	5.4135
Color	Colorless with Green Inclusions
Shape/Cut	Faceted Oval
Length (mm)	13.90
Width (mm)	9.98
Depth (mm)	6.76
Mass Volume (g/cm^3)	2.652

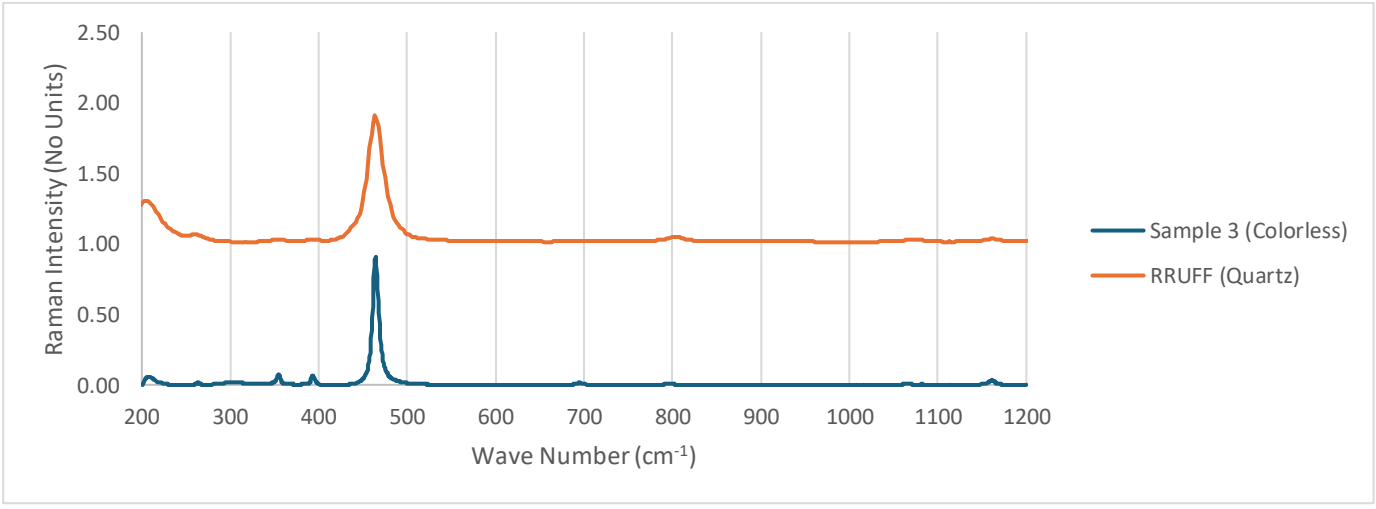
Classic Gemology:

Refractive Index	1.54-1.55
Birefringence	0.01
Optic Figure	AGG
UV Shortwave	Inert
UV Longwave	Inert

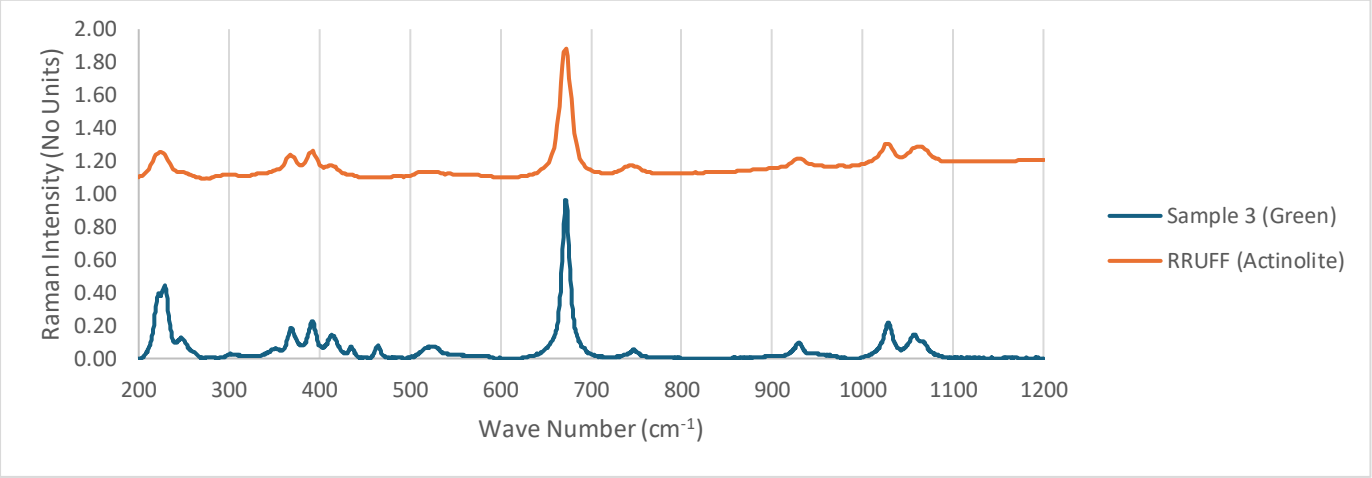
This gemstone was easy to determine using classical gemology, but advanced testing made determining the inclusion easy. Without testing the stone looked like an olive-green needles filled (sagenitic) colorless quartz. The RI of 1.54-1.55 made quartz the best option even with the AGG polariscope reading. The polariscope readings are likely created via the inclusions affecting the gemstone. Even though the author could not find a bull's-eye, with the SG of 2.652, classic gemology confirmed quartz. The green color of the needles indicated actinolite (see images 7 and 8).

Images 7 and 8: Actinolite in quartz at 60x

Advanced Gemology:



Graph 3: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 10 scans of 10 seconds. The spectra matched quartz well but did not pick up the numerous inclusions for most of the tests. RRUFF database sample R050125 quartz from Linopolis, Minas Gerais, Brazil had a 98% match.



Graph 4: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired, with 10 scans of 10 seconds. After several tests, eventually the inclusion was detected. Though there is much noise, the peaks match up nicely with Actinolite. The RRUFF R040063 from Harford County, Maryland, USA was a 91% match.

Advanced gemology easily confirmed the host stone to be quartz. After several tests, eventually the inclusion was detected. Using Micro-Raman, the green needles are confirmed to be actinolite. Though there is a lot of noise, the peaks match up nicely with Actinolite. The RRUFF R040063 from Harford County, Maryland, USA was a 91% match. The peaks matched with the quartz and the actinolite (see graphs 3 and 4).

Quartz has a main single peak at 464cm^{-1} that is related to bending vibrations on the intra-tetrahedral O-Si-O angles (Enami et al., 2007).

Actinolite has a main peak at 671cm^{-1} due to the symmetric stretching vibration (v_s) of the Si-Ob-Si bridge. A lower notable peak is 224cm^{-1}, due to lattice modes. A higher notable peak is 1059cm^{-1}, from asymmetric stretching vibrations (v_{as}) of the Si-Ob-Si bridges (Zheira et al., 2022).

Conclusive Remarks

Supported by the classical gemology quartz results, it is safe to say that quartz is the host gemstone. Classic gemology was adequate to determine the host material and enough to make an informed guess on the inclusions, but advanced gemology was the only way to be certain about the inclusion.

Quartz is an extremely common mineral throughout the world and the jewelry industry. Quartz can be very transparent and therefore show off inclusions well. Quartz can have various mineral inclusions and can form in a range of conditions. Solid inclusions that form fibers and hairline within quartz commonly are rutile, tourmaline, and actinolite (Zhao et al.,2024).

Actinolite needles in quartz can be found from a variety of locations, including Pakistan, and have been of interest in the gemstone trade. The needles can form dense networks and affect the overall appearance of the quartz (Laurs & Renfro, 2017). Actinolite can be yellowish green to green. The green color is from iron (Gemological Institute of America, 1995).

Sample #04

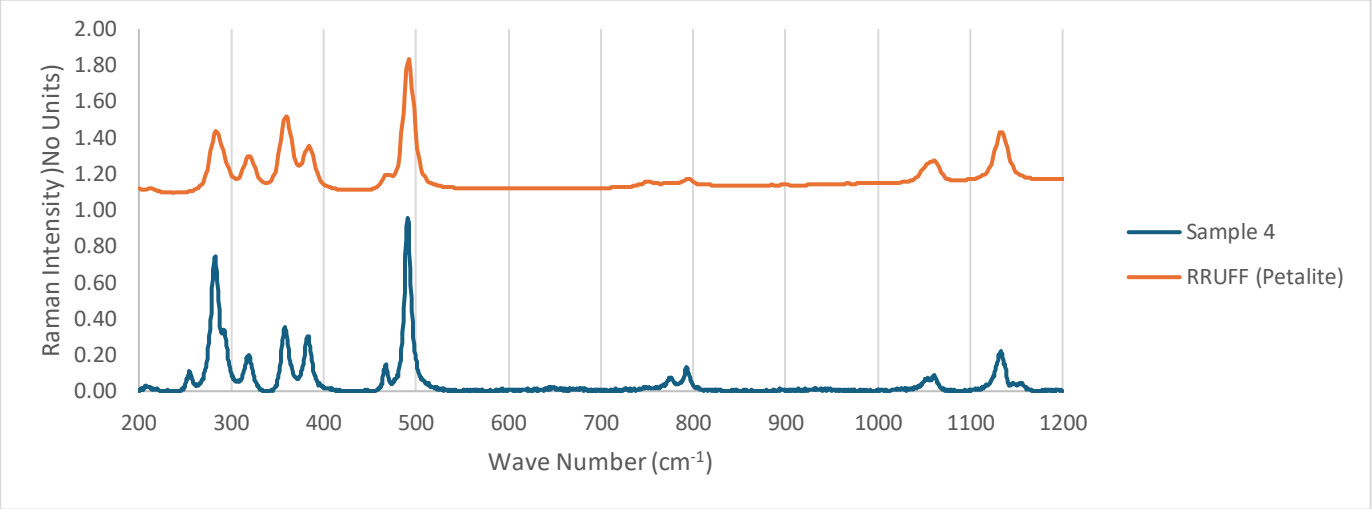
Gemstone	Petalite
Sample Name	SPM-JRUS-04
Weight (ct.)	0.3525
Color	Colorless
Shape/Cut	Faceted Oval
Length (mm)	6.12
Width (mm)	4.13
Depth (mm)	2.63
Mass Volume (g/cm^3)	2.389

Classic Gemology:

Refractive Index	1.503-1.514
Birefringence	0.011
Optic Figure	DR
UV Shortwave	Weak White
UV Longwave	Weak Yellow

This colorless stone without testing could be a wide variety of different gemstones. Colorless gemstones are difficult to sight identify accurately. The RI of 1.503-1.514 and DR do not match anything in the GIA Lab Manual. The GIA Reference Guide has petalite and it is within the range. The SG is 2.389 and weak white or orange fluorescence is close (yellow) to the reference data. While this stone would be difficult to impossible to determine using the most basic of classic gemology tests and the lab manual (not listed), conducting the full range of tests and having knowledge of the stones in the reference guide, made it possible to determine the stone's identity.

Advanced Gemology:



Graph 5: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 10 scans of 10 seconds. Spectra compared with the RRUFF had a 95% match with Petalite R040100 from Brazil

Advanced gemology made for very easy gemstone determination. The T64000 results matched the RRUFF database with a 95% match with Petalite R040100 from Brazil. The peaks matched. Colorless gemstones are always hard (see graph 5).

The most distinct peak is at 490cm^{-1} and this is from symmetric bending vibrations of silicate tetrahedra (SiO_4) (Stubna, 2024).

Conclusive Remarks

Petalite is more of a collector stone than a gemstone, as there are many superior alternatives. Petalite is mainly significant as a lithium ore. The name is derived from petalion, a Greek word, meaning blade or leaf (Stubna, 2024). Colorless Petalite in the gemstone industry is usually linked with mining for tourmaline and other gemstones. Gem quality petalite can be found in lithium rich granitic pegmatites. It can be colorless to yellow or gray (Emerson, 2009). But Pink and light green have been reported (Gemological Institute of America, 1995).

Sample #05

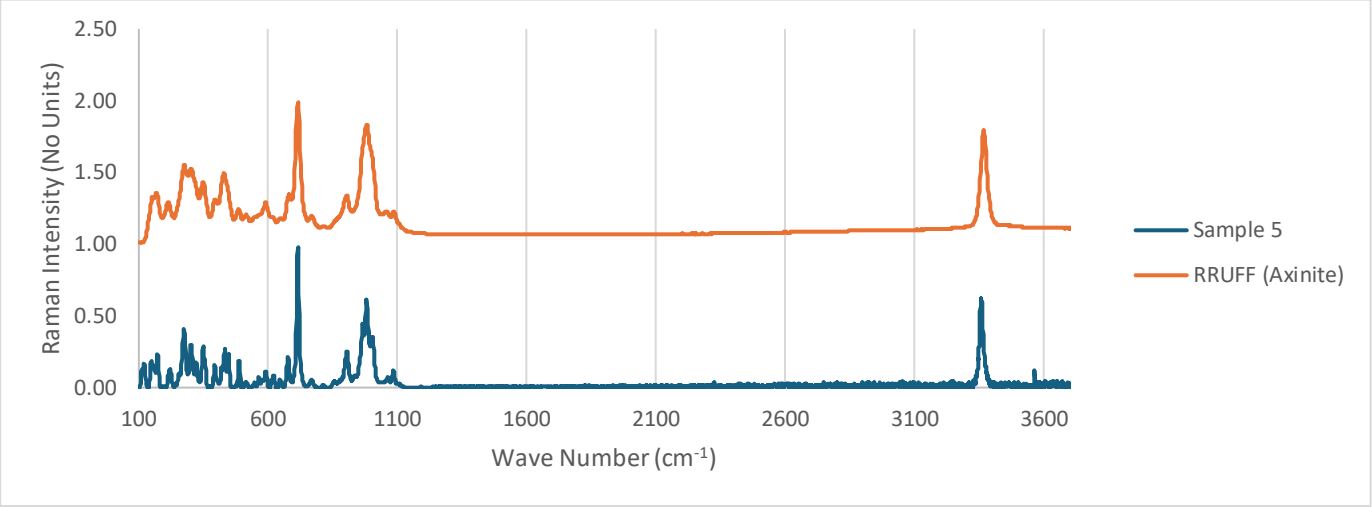
Gemstone	Axinite
Sample Name	SPM-JRUS-05
Weight (ct.)	2.1875
Color	Light Brown
Shape/Cut	Faceted Pear
Length (mm)	11.55
Width (mm)	7.15
Depth (mm)	4.47
Mass Volume (g/cm^3)	3.232

Classic Gemology:

Refractive Index	1.657-1.667
Birefringence	0.01
Optic Figure	DR
UV Shortwave	Inert
UV Longwave	Weak Orange

This gemstone is light brown and has a range of possibilities, including smokey quartz, without testing. The RI is 1.657-1.667 and DR, so it does not really match anything well in the GIA Lab Manual (does not include axinite). The closest options are spodumene or enstatite, but the RI goes too high. The GIA Gem Reference Guide lists axinite's RI as 1.678-1.688 (+/-.005) which is higher than the reading, adding further confusion. The measured SG was 3.232 which is just at the limit of the range of axinite's 3.29(+.07, -0.03). Even by looking at pleochroism, determining the identity of the stone would be a partial guess.

Advanced Gemology:



Graph 6: Raman spectra were obtained on a Renishaw Micro-Raman and hade a 94% match with axinite RRUFF R060194 sample stone.

Using advanced gemology was also not straight forward. FTIR and FT Raman all had noise and unclear results. The Renishaw Micro-Raman worked very well. The spectra had a 94% match with sample axinite RRUFF R060194 from near Dalbandi, Baluchistan Province, Pakistan, as well as a few others (see graph 6). Axinite is usually a challenging stone to identify with a high degree of confidence with classic gemology. Combined with advanced gemology it was easy to determine the identity of the gemstone.

The most predominant peaks are714cm^{-1}, 980cm^{-1}, and 3363cm^{-1}. The intense 714cm^{-1} peak is attributed to OBO bending modes. The 980cm^{-1} is ascribed to SiO stretching vibrations. The 3363cm^{-1} peak is related to OH stretching vibrations. Axinite has many minor bands, those between 100-500cm^{-1} are related to FeO stretching vibrations, and those between 500-700cm^{-1} are attributed to bending modes of the (SiO4)2- units (Frost et al., 2007).

Conclusive Remarks

Axinite is a rare gemstone in the jewelry industry and almost exclusively a collectors stone. Brown is the most common color, but yellow, blue, orange, purple and pink are also seen. Unlike many collector stones, Axinite has good hardness at 6-7 Mohs. Fe-type Axinite is the most prevalent, but Mg and Mn can be gem quality. Iron rich axinite is brown (Vigier & Fritsch, 2020).

Sample #06

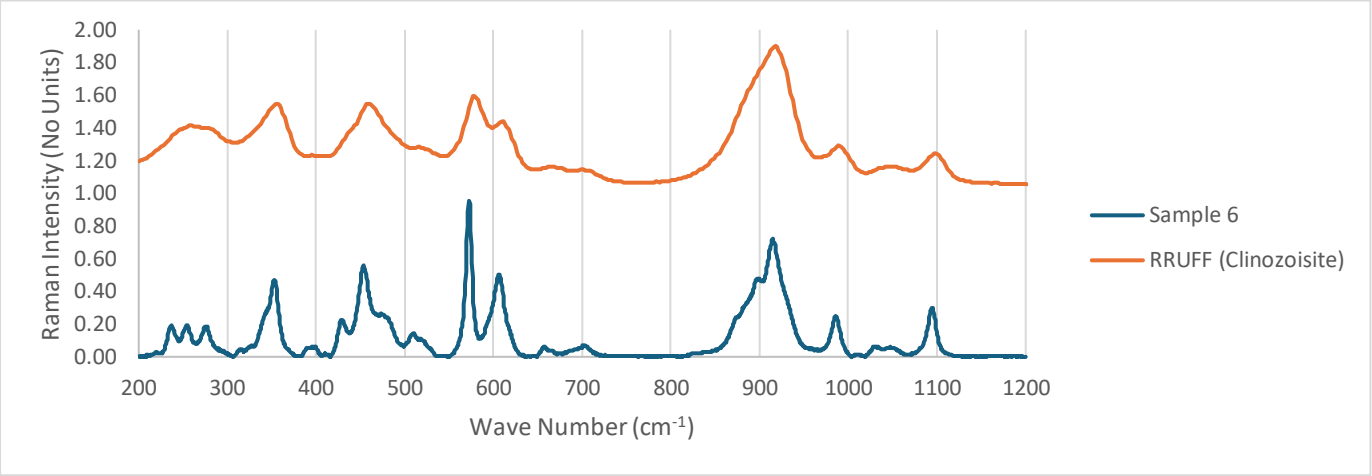
Gemstone	Clinozoisite
Sample Name	SPM-JRUS-06
Weight (ct.)	2.0380
Color	Brown
Shape/Cut	Faceted Cushion
Length (mm)	7.57
Width (mm)	7.56
Depth (mm)	4.84
Mass Volume (g/cm^3)	3.387

Classic Gemology:

Refractive Index	1.712-1.719
Birefringence	0.007
Optic Figure	DR
UV Shortwave	Inert
UV Longwave	Inert

This brown gemstone could be a range of different gems, including smokey quartz, just off sight. The RI was 1.712-1.719 and it was DR. Using the GIA Lab Manual, Idocrase matches up very well. The SG is 3.387, which is within range of idocrase and epidote. Without doing any more testing, idocrase would be the result as epidote has an RI just a little higher.

Advanced Gemology:



Graph 7: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 10 scans of 10 seconds. The gemstone had a 97% match with Clinozoisite RRUFF R060284.

Advanced testing was the best way to determine what the stone is. Using the T64000 the gemstone had a 97% match with Clinozoisite RRUFF R060284 from near Zagi Mountain, Khaffor Dehri, North-West Frontier Provence, Pakistan. The peaks matched (see graph 7). The collected spectra was higher resolution than the reference spectra.

Clinozoisite has several diagnostic bands and several main bands. The diagnostic bands are 570cm^{-1}, 980cm^{-1}, and 1090cm^{-1}. The 570cm^{-1} peak is attributed to Si-O-Si bending modes. The 980cm^{-1} and 1090cm^{-1} are related to Si-O bond stretching modes. These can be used to separate Clinozoisite from epidote and zoisite. The main bands are 455cm^{-1}, 570cm^{-1} (also diagnostic), and 917cm^{-1}. The peak at 455cm^{-1} is related to Si-O_b-Si stretching. The peak at 917cm^{-1} is related to Si-O_{nb} stretching. Less predominant peaks like 237cm^{-1} and 256cm^{-1} are attributed to transitions of cations or anionic groups. The 276cm^{-1} band is related to Ca-O stretching vibrations. The medium intensity band at 35 is attributed to Al-O or Fe-O stretching vibrations. The 608cm^{-1} peak is related to Si-O_b stretching (Limonta et al., 2022).

Conclusive Remarks

Relying on only classic gemology would be very difficult to get the correct stone identity. As the test results match several stones.

Clinozoisite is part of the epidote group. Clinozoisite can be colorless, green, yellow, and pink when transparent. (Bernard & Jaroslav, 2015). Clinozoisite can also be brown and gem material is rare above 5ct. The gemstone is better suited as a collector stone, as it is only 6-7 Mohs, has perfect cleavage in one direction, and fair to poor toughness (Gemological Institute of America, 1995).
The more iron content in Clinozoisite, the higher the refractive index, birefringence and the specific gravity (Fritz et al., 2007).

Sample #07

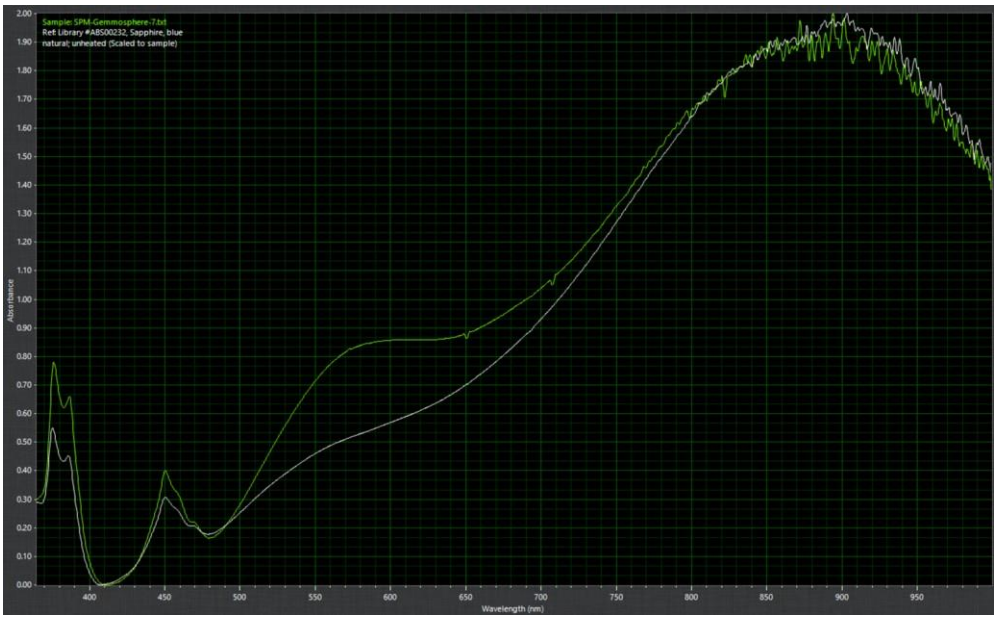
Gemstone	Sapphire
Sample Name	SPM-JRUS-07
Weight (ct.)	2.1875
Color	Dark Blue with Colorless Color Zoning
Shape/Cut	Faceted Oval
Length (mm)	9.97
Width (mm)	7.74
Depth (mm)	2.86
Mass Volume (g/cm^3)	4.018

Classic Gemology:

Refractive Index	1.763-1.771
Birefringence	0.008
Optic Figure	DR, Uniaxial
UV Shortwave	Inert
UV Longwave	Inert

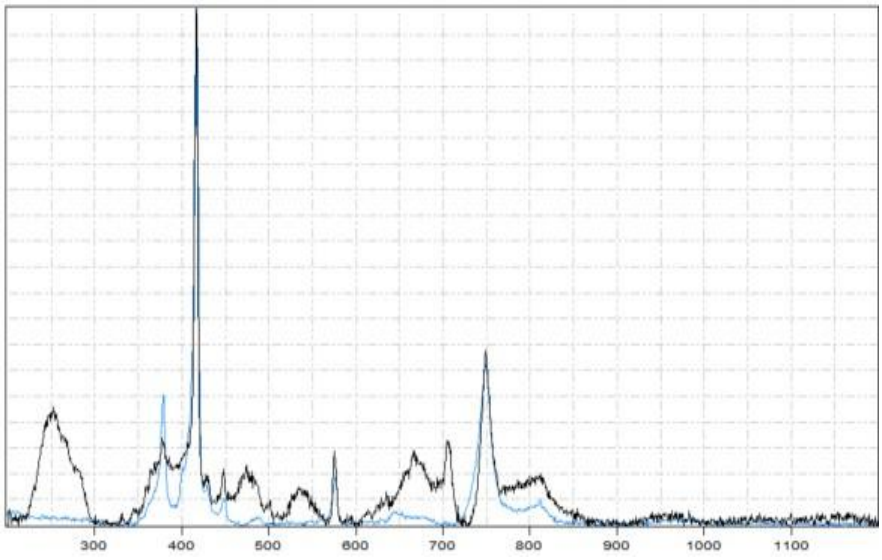
This stone without doing any tests looks like it could be sapphire or very nice blue kyanite. It has strong blue and colorless streaking zoning and is cut to be shallow. The bag the stone was in, was labeled top grade kyanite. The RI was 1.763-1.771 and the optic figure was DR Uniaxial. This confirmed sapphire and eliminated kyanite as an option. The SG further confirmed sapphire.

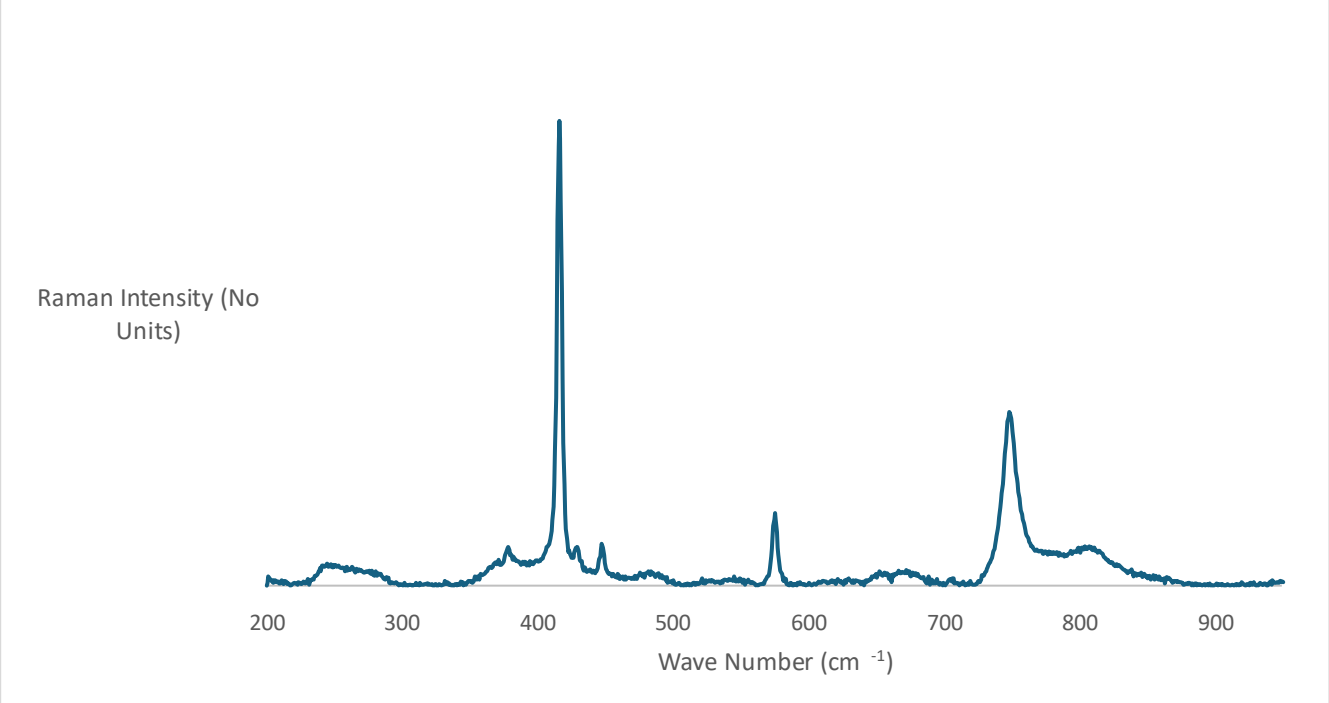
Advanced Gemology:



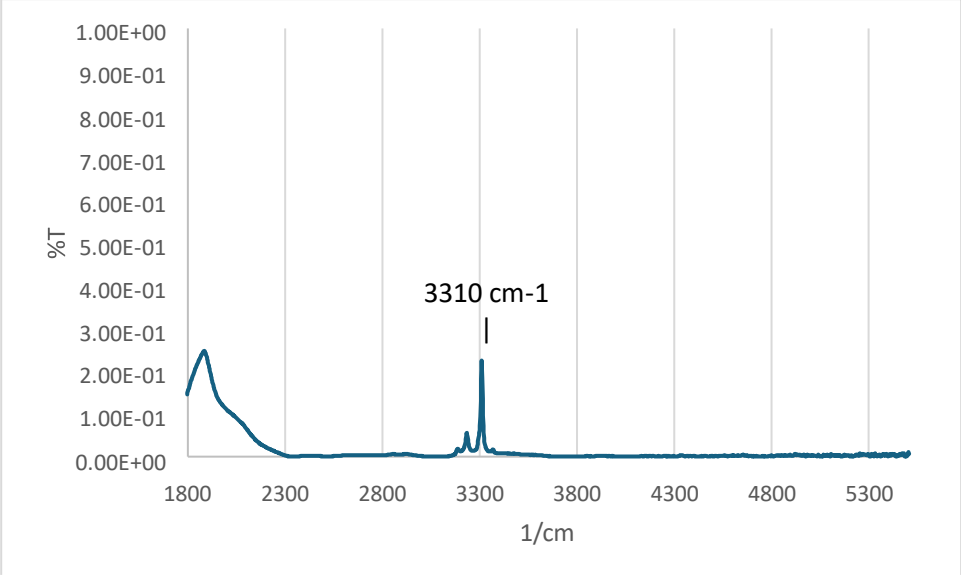
Graph 8: 89% match with MAGI library ABS00232 magmatic type unheated blue sapphire from Mambila, Nigeria. The integration time was 450 seconds, with 230 averages.

Graph 9: T64000 data matches RRUFF database R060020 corundum from Yogo Gulch, Montana, USA 83%.





Graph 10: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired between 200 and 1200 cm^{-1}, with 10 scans of 10 seconds. Graph scale range between 200 and 1000 cm^{-1} for improved readability.



Graph 11: Brucker Vertex made a FTIR spectra was recorded in the 1800-5500 cm^{-1} range with 1000 scans and 4 cm^{-1} spectral resolution in transmission/reflection mode.

Advanced gemology using several devices gave useful information. The T64000 matched the spectra peaks for sapphire very well. With RRUFF database R060020 corundum from Yogo Gulch, Montana, USA 83% match (See graphs 9 and 10). MAGI Gemmosphere also gave useful information and though the database is limited, it does do sapphire well (see graph 8).The Brucker Vertex showed a 3310cm^{-1} peak (see graph 11).

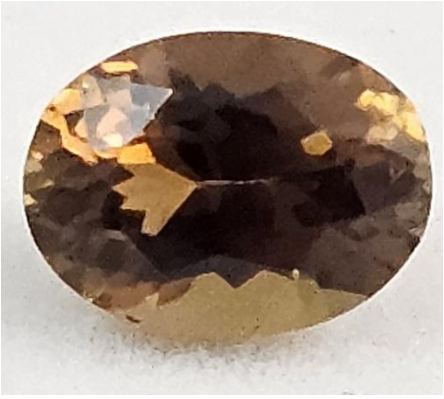
The main 418cm^{-1} peak and lesser 379cm^{-1} and 750cm^{-1} are attributed to E_g phonon mode (Liu et al., 2015) Other sources go into greater detail and describe the 415cm^{-1} and 377cm^{-1} peaks to be related to displacements caused by internal structural deformation. The 749cm^{-1} peak is associated with Al-O stretching vibration (Zhao et al., 2021).

Conclusive Remarks

Classic gemology was sufficient to determine the stone identity. Advanced gemology was very fast and several methods worked to determine the stone identity.

Sapphire has been one of the most desirable stones, especially in blue for millennia across the world. While the name's origin is unclear, the French used safir in the 13th century and Greeks used sappheiros. When pure the stone is colorless. Blue Sapphire is colored from iron 2+ and Titanium 4+ (Hughes et al., 2017). Sapphire forms or is transported with a variety of methods, which can have an impact on appearance. Alkaline basalt type sapphires may have a 3310 cm^{-1} infrared absorption peak, but this is not enough to determine geological environment (Chen et al., 2021).

Sample #08



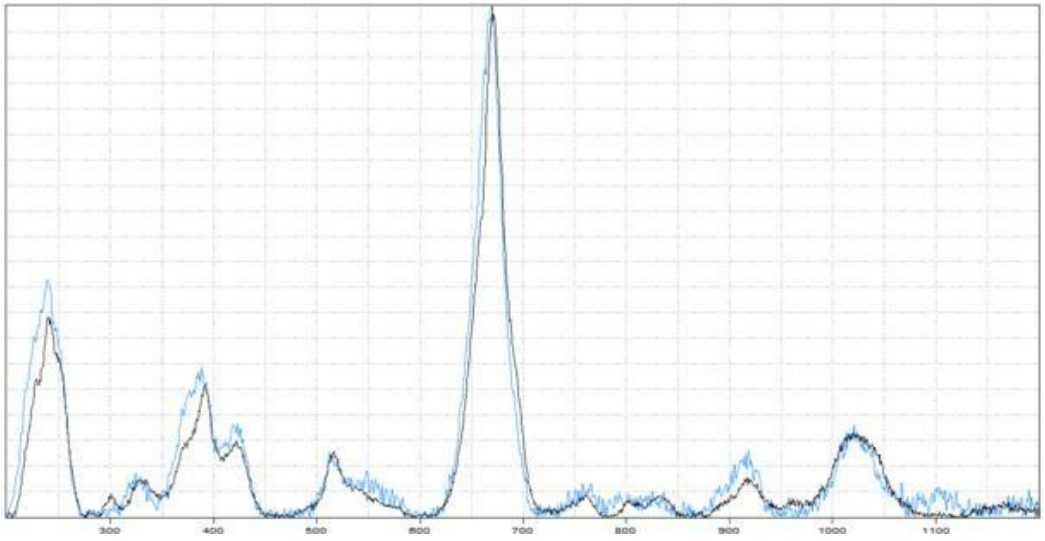
Gemstone	Pargasite
Sample Name	SPM-JRUS-08
Weight (ct.)	0.7530
Color	Slightly orangish Brown
Shape/Cut	Faceted Oval
Length (mm)	6.82
Width (mm)	5.09
Depth (mm)	3.59
Mass Volume (g/cm^3)	3.083

Classic Gemology:

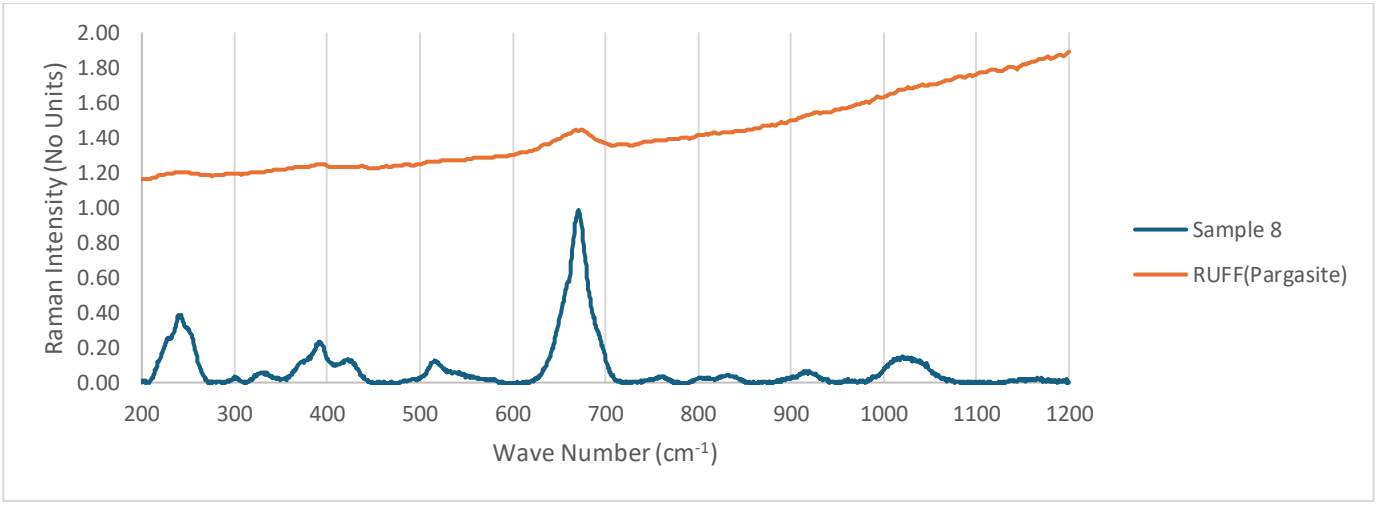
Refractive Index	1.622-1.638
Birefringence	0.016
Optic Figure	DR
UV Shortwave	Moderate Yellow
UV Longwave	Inert

This brown gem could be a range of stones from sight identifying. The RI was 1.622-1.638 and it was DR. Using the GIA Lab Manual, the closest options would be tourmaline or topaz. The SG was 3.083, which eliminated topaz. Without doing any more tests, tourmaline might be reasonable. But if UV was tested the results would be confusing, as tourmaline is generally inert. As the Lab Manual or the Reference Guide do not cover this gemstone, it would probably be misidentified.

Advanced Gemology:



Graph 19: T64000 matching 98% match with Pargasite RRUFF R050321 from Soper River, Near Kimmirut, Baffin Island, Nunavut, Canada.



Graph 20: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 10 scans of 10 seconds.

Through advanced testing more and better matches emerge. The T64000 data had a 98% match with Pargasite RRUFF R050321 from Soper River, Near Kimmirut, Baffin Island, Nunavut, Canada. The GIA material did not cover this unusual collector stone. Using only GIA's resources would be insufficient to determine the correct stone identity (see graphs 19 and 20). The spectra did not match up well outside of CrystalSleuth (graph 20).

Pargasite has its most predominant peak at 667cm^{-1} and this is ascribed to $v_s(v_1)$ of the Si-O_b-Si. The spectral region between 1000-1100cm^{-1} is related to asymmetric stretching vibration of the Si-O_b-Si bridge (Apopei & Buzgar, 2010).

Conclusive Remarks

Pargasite is a collector stone and rarely seen faceted. The gem can be green, brown, white or black. In brown gemmy material from Mogok, large crystals can be found. The stone is 5-6 Mohs hardness, and has perfect cleavage, which excludes it from being a durable gemstone (Bernard & Jaroslav, 2015).

Sample #09

Gemstone	Sapphire
Sample Name	SPM-JRUS-Sapphire
Weight (ct.)	2.826
Color	Dark Blue
Shape/Cut	Round Faceted
Average Diameter (mm)	8.85
Depth (mm)	4.61
Mass Volume (g/cm^3)	3.991

Classic Gemology:

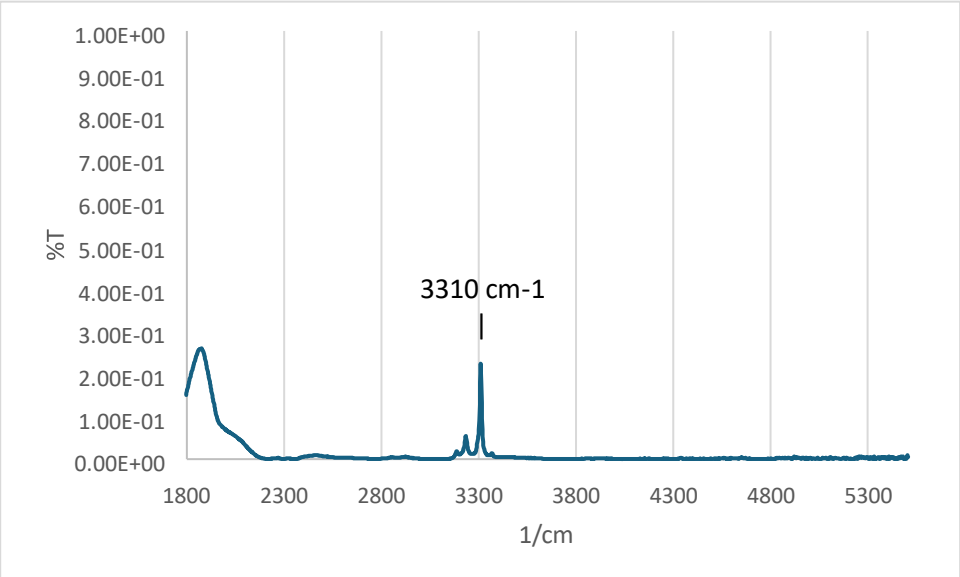
Refractive Index	1.762-1.771
Birefringence	0.009
Optic Figure	DR, Uniaxial
UV Shortwave	Inert
UV Longwave	Inert

This very dark blue round gemstone looks like a sapphire without testing. The RI is 1.762-1.771 and the optic figure is DR Uniaxial. Sapphire is the best choice with just these tests. The visible hexagonal zoning supported sapphire. The SG is 3.991, further solidifying this conclusion.

Advanced Gemology:

75% match Corundum R040096 from Sri Lanka

Graph 21: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired between 200 and 1000 cm^{-1}, with 6 scans of 30 seconds.



Graph 22: Brucker Vertex made a FTIR spectra was recorded in the 1800-5500 cm^{-1} range with 1000 scans and 4 cm^{-1} spectral resolution in transmission/reflection mode.

Advanced Testing with the T64000 confirmed the sapphire identity (see graph 21). Unfortunately, the spectra file on the RRUFF database website that best matched (91% R060020) did not have the correct file to download. So the next best match(75% R040096 from Sri Lanka) is used for the graph.

See advanced gemology section under sample 8 for Raman spectra study.

Conclusive Remarks

Classic gemology was enough to determine the identity of the stone, but advanced gemology is sufficient as well.

Sample #10

Gemstone	Fuchsite (Muscovite)
Sample Name	SPM-JRUS-10
Weight (ct.)	2.8695
Color	Green
Shape/Cut	Cabochon Oval
Length (mm)	10.10
Width (mm)	8.01
Depth (mm)	4.41
Mass Volume (g/cm^3)	2.84

Classic Gemology:

Refractive Index	1.51 spot
Birefringence	-
Optic Figure	AGG
UV Shortwave	Inert
UV Longwave	Strong Chalky Green

The stone was waxy green and resembles plastic at first look. The stone looked like it may have a coating, but further investigation showed it to be a patchy somewhat phyllitic texture. Under magnification and good lighting tiny orange spots (see image 9) could be observed. The stone had orange inclusions, several surface reaching. The spot RI was 1.51 and under the polariscope it stayed light as it was rotated (AGG). Using the GIA Lab Manual and Reference Guide, this reading does not match anything. The SG was 2.84. So this would be a very tricky if not impossible stone to identify using GIA's literature.

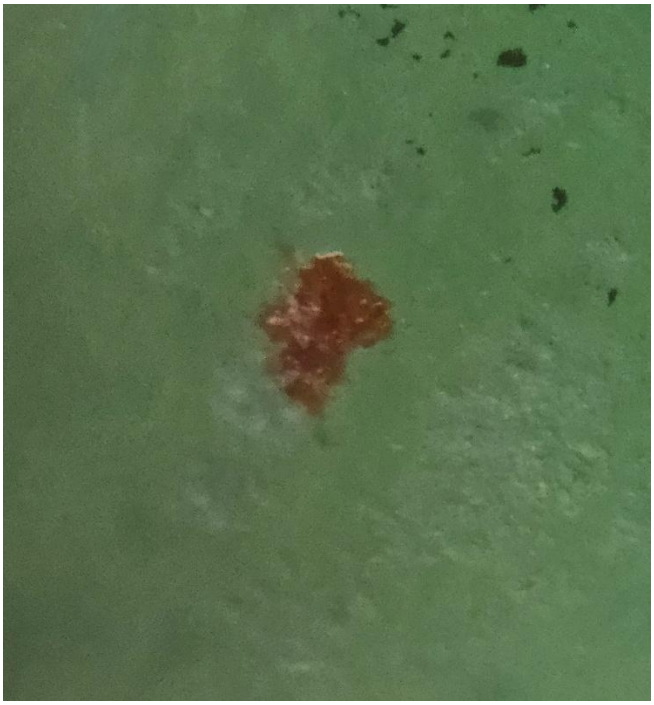
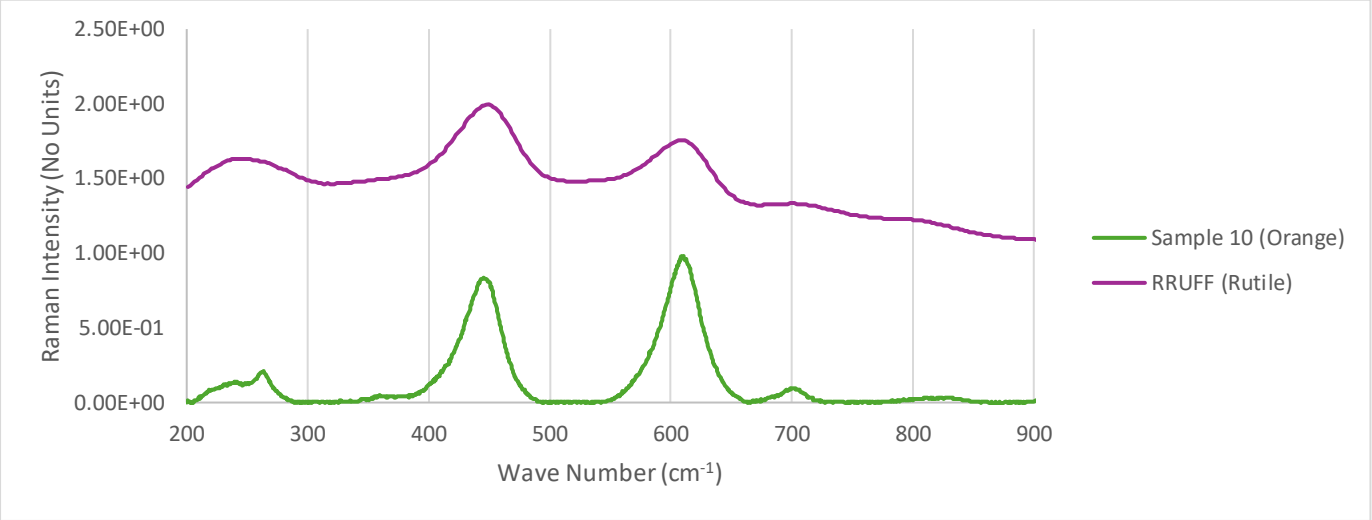
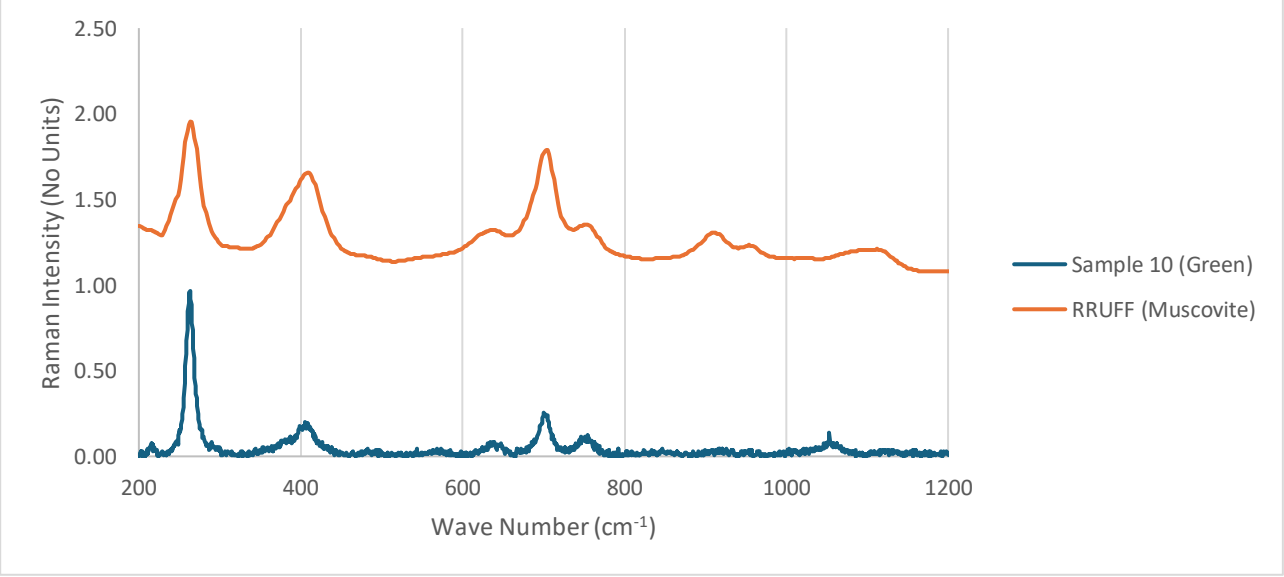


Image 9: 60x image of orange (rutile) surface reaching inclusion.

Advanced Gemology:



Graph 23: Micro-Raman scattering spectra were measured using theT64000. The spectra were acquired between 200 and 1200 cm^{-1}, with 3 scans of 5 seconds. Spectra scaled limited to 200to 900 cm^{-1} for improved readability. The collected spectra had a 97% match with Muscovite RRUFF R060182 from Reliance mine, Mica Mountain, Tete Juane Cache, British Columbia.



Graph 24: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired between 200 and 1400 cm^{-1}, with 3 scans of 10 seconds. Spectra scaled from 200 to 1200 cm^{-1} for readability.

Advanced testing is the best way to go further. Using the T64000 the host gemstone was easily tested as 97% match with Muscovite RRUFF R060182 from Reliance mine, Mica Mountain, Tete Juane Cache, British Columbia (see graph 23). Using reference literature, the chromium rich variety of muscovite was the best option. Though difficult to test the orange inclusions, eventually with the T64000, a spectra that did not match the host material was collected. The spectra matched rutile (See graph 24) and matched 98% with sample Rutile R050031 from Chester City, Pennsylvania, USA.

Fuchsite was very difficult to research. The author took a broader approach and had success with using muscovite micas as analog. The wave number for the peaks can shift with the $Al^{(iv)}$ content. The main peak in the measured spectra was slightly lower than the one found in the reference spectra, this is attributed to increasing $Al^{(iv)}$ present. The main peak observed is 263cm^{-1} and the literature has it at 270cm^{-1} and this is related to symmetrical stretching of the isosceles triangle O-H-O. The second highest peak is 408cm^{-1} and attributed to overlapping of the (OH) libration and Si-O vibration. The 640cm^{-1} and 1040cm^{-1} peaks involve tetrahedral sites or Si-O-Al vibrations. The 702cm^{-1} peak is related to Si-O-Si vibrations (Tlili et al., 1989).

The rutile that was detected had main peaks at 447cm^{-1} and 612cm^{-1}. The 447cm^{-1} is related to E_g Vibration mode. The 612cm^{-1} peak is associated with A_{1g}(Maftei et al., 2020). The E_g mode is symmetric stretching vibration of O-Ti-O and the A_{1g} mode is anti-symmetric bending vibration of O-Ti-O (Ekoi et al., 2019).

Conclusive Remarks

The author had not encountered fuchsite before and using only GIA's standard reference material was not able to determine positively what the stone was and had to use advanced equipment to make the identification. The GIA reference material does not list this species of gemstone. GEM-A's journal did have a recent article that covered the gemstone. While the appearance and SG did match, the RI and reaction under UV color were different. The measured spot RI was 1.51, the article was 1.56-1.57. Spot RI is difficult to measure and less accurate than traditional measurements. (Blumentritt et al.,2024). But the Raman results with the classic gemology

Fuchsite is the chromium variety of muscovite. Chromium is the cause of the green color. It has perfect cleavage and 2.5-3 Mohs (Bernard & Jaroslav, 2015). Fuchsite has been found to have rutile inclusions. Fuchsite from Bahia, Brazil can have reddish orange rutile disseminated evenly throughout (Schultz-Guttler, 2005). African fuchsite with rutile inclusions has been described as platy polyhedral and brown colored. Fuchsite is a collector's stone and not suitable for jewelry. It has been presented as an emerald imitator, but only in appearance (Pradat et al., 2013).

Sample #11

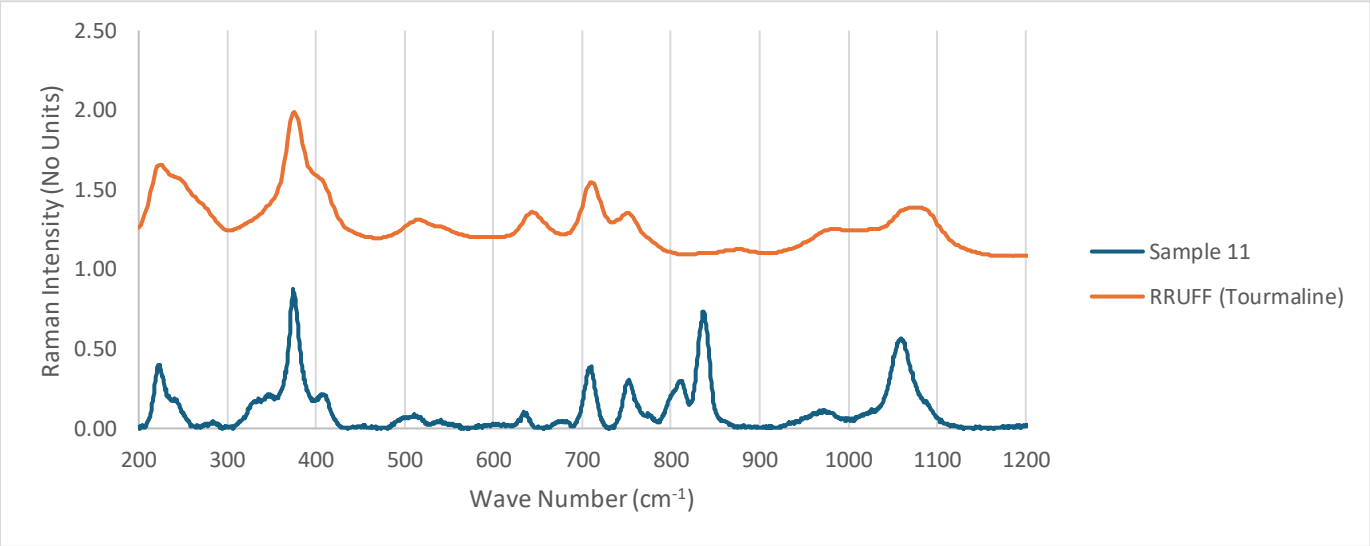
Gemstone	Tourmaline
Sample Name	SPM-JRUS-11
Weight (ct.)	3.0210
Color	Dark Green with Bluish Green Color Zoning
Shape/Cut	Faceted Rectangle
Length (mm)	10.18
Width (mm)	7.08
Depth (mm)	4.63
Mass Volume (g/cm^3)	3.065

Classic Gemology:

Refractive Index	1.622-1.641
Birefringence	0.019
Optic Figure	DR
UV Shortwave	Inert
UV Longwave	Inert

This green gem looks like a tourmaline without doing any tests. The step cut is very popular with the material. The visible pleochroism along the long axis of the stone gives it away. The RI was 1.6221.641 and DR, confirming tourmaline. The SG 3.065 further confirmed tourmaline. Classic gemology was enough to determine the species, but not the variety of this stone.

Advanced Gemology:



Graph 25: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired between 200 and 1200 cm^{-1}, with 10 scans of 10 seconds.

The spectra had a 85% match with RRUFF sample R050119 elbaite tourmaline from Cruziero mine, San Jose, Minas Gerais, Brazil (see graph 25) as well as good matches with dravite from Tanzania, The peaks matched well in the most part. The 223 cm^{-1} peak (graph 25) indicated that the stone might have Mg-O stretching vibration and would indicate dravite (Chen, 2024).

The presence of peaks at 215±2cm^{-1} and 244±2cm^{-1} are attributed mostly to Mg-O stretching and the absence indicated elbaite, where Al and Li are substituted for Mg. The collected spectrum has a significant peak at 223cm^{-1} but is somewhat broad and may integrate the 217cm^{-1} and 246cm^{-1} peaks. The 374±2 cm^{-1} peak are seen in dravite and elbaite due to Al-O stretching vibration. This major peak is very distinct in the collected spectra. Peaks between 600-750cm^{-1} are related to Si-O vibrations (Fantini et al., 2013).

Other interpretations for the 600-800cm^{-1} are symmetrical Si-O-Si vibration. Peaks between 800-1100cm^{-1} are due to AlO_6 and BO_3 deformations, Al-O stretching, BO3 breathing, O-Al-O, Si-O, and B-O motion. The 840cm^{-1} peak (see graph 25) is due to OH stretching vibrations (Hoang et al., 2011).

Conclusive Remarks

Advanced gemology agreed with the classic result for species, tourmaline. The stone variety is most likely either elbaite or dravite. Unfortunately, the test results for chemical analysis were not found and could not be factored into the decision. If further tests could be compared, the variety of tourmaline could be determined.

Sample #12

Gemstone	Green Coated Synthetic Colorless Sapphire
Sample Name	SPM-JRUS-12
Weight (ct.)	1.9660
Color	Light Green
Shape/Cut	Faceted Oval
Length (mm)	8.64
Width (mm)	6.50
Depth (mm)	3.86
Mass Volume (g/cm^3)	3.981

Classic Gemology:

Refractive Index	1.740-1.743(before polishing), 1.760-1.768(after polishing)
Birefringence	0.003(before), 0.008(after)
Optic Figure	DR, Uniaxial
UV Shortwave	Weak White
UV Longwave	Inert

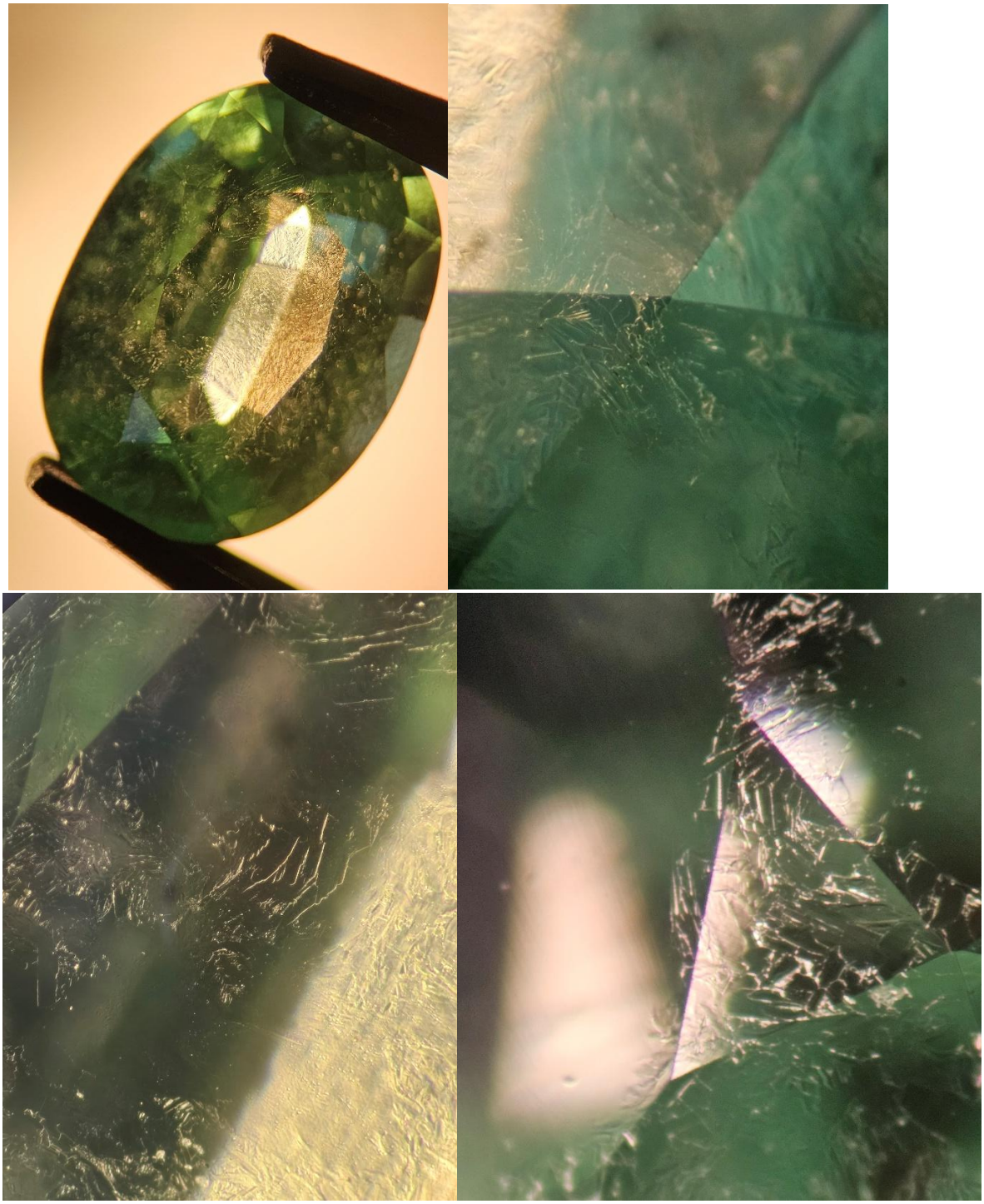
The stone was labeled Gross, probably for grossularite garnet. The eye clean, light minty green oval resembles readily available commercial grade grossularite garnet with an oily surface. If only considering the appearance and the 1.74 refractive index and an easily missed 0.003 birefringence, grossularite garnet is a totally reasonable assumption. But if other tests were performed and considered, the stones identity determination would be not entirely strait forward.

This unusual stone has several classical gemology test results indicating it to be possibly sapphire, including the 3.98 SG, DR uniaxial optic character. But the RI tested at 1.74 (retested and confirmed with GIA, GEM-A, and Japanese refractometers), which is far too low to be sapphire.

The surface with the naked eye and 10x loupe looks to be slightly dirty with an oily or sticky appearance (see image 10). Under magnification above 40x the facets appears to be minute surface penetrating feathers. When looking at facet junctions at and above 60x, the feathers do not pass into the stone and are isolated to the coating (see image 11). They have an overall dendritic pattern across almost the entire stone (see image 12).

The gemstone is internally clean of inclusions and immersion yields even coloration.
Overnight soakings in acetone and then ethanol did not affect the coating or RI reading. With the permission of the owner, the stone's table was re-polished by AGTA Spectrum Award winning lapidary Ai Van Pham of Scottsdale, AZ. The stones refractive index was then retested at the table and gave the expected 1.760-1.768 range, with 0.008 birefringence. The texture of the re-polished area was smooth and highly reflective surface (see image 13).

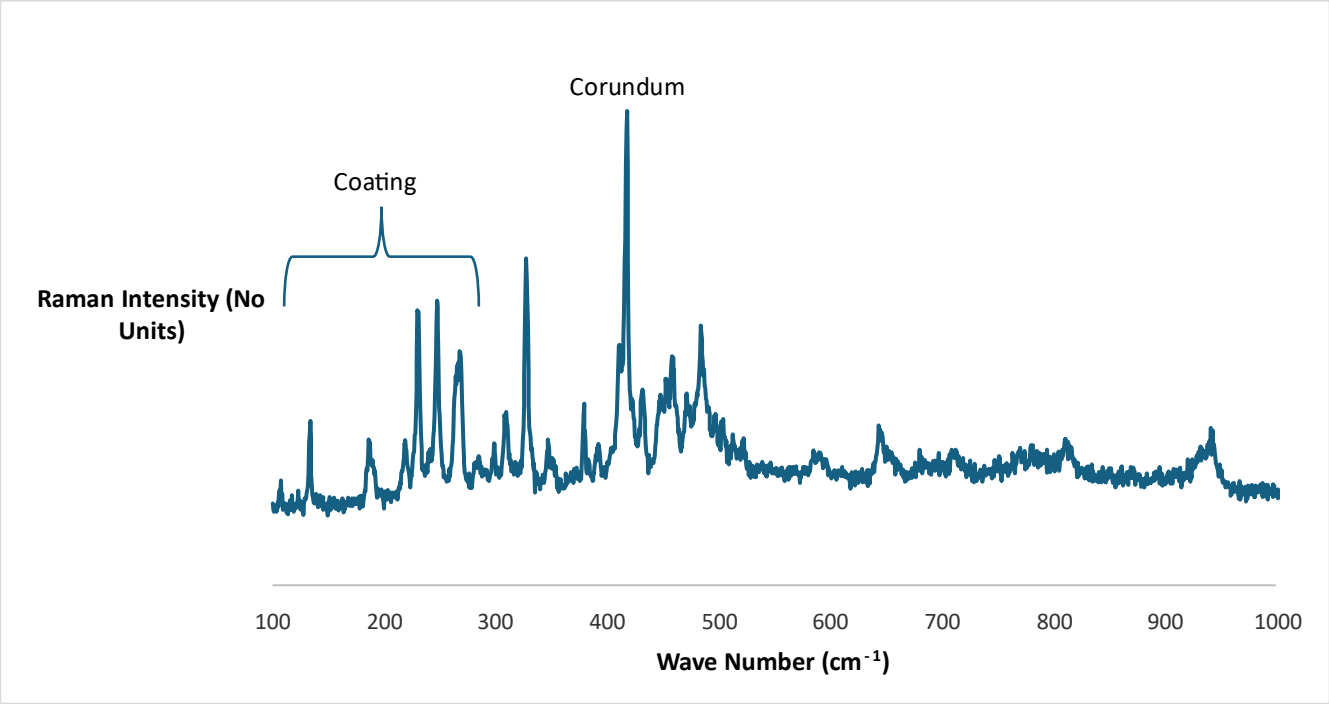
With the better RI from the polished table, the results painted a more clear picture; natural or synthetic sapphire.



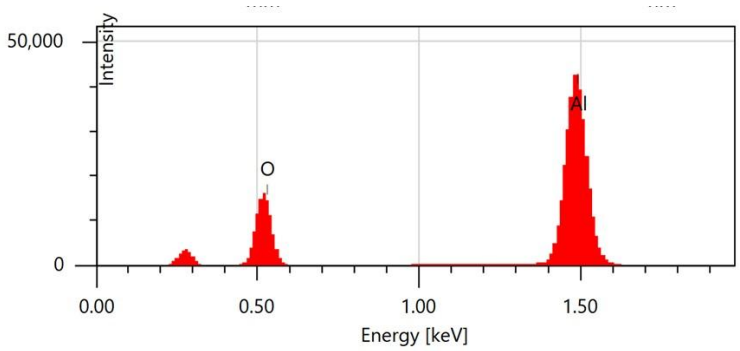
Images 10-13: of the coated sapphire (image 10:The overall dirty appearance of the stone at 30x-top left, image 11: under 60x magnification the facet junctions can be seen underneath the crackled surface-top right, image 12: at 40x the table is mottled-bottom left, image 13: the table and facet junction after the table was polished at 60x-bottom right)

The stone had weak chalky white fluorescence under short wave UV. Natural colorless sapphire has “inert to moderate red to orange under LW and SW” fluorescence, and synthetic has “inert to weak bluish white (pg. 309 GIA Gem Identification Lab Manual)” fluorescence. Considering the lack of observable natural inclusions and the white fluorescence, flame fusion synthetic colorless sapphire is the underlying gem material. The final verdict is green coated synthetic flame fusion colorless sapphire.

Advanced Gemology:



Graph 26: Horiba Scientific LabRAM HR Evolution was used to kindly retest the sample by prof Boris Chauviré. The spectra was measured with a 532nm laser. The spectra were acquired between 100 and 1000 cm^{-1}, with 5 scans of 5 seconds.



Display name	Standard data	Quantification	Result Type
Spc_013	Standardless	ZAF	Metal

Element	Line	Mass%	Atom%
O	K	43.40±0.14	56.39±0.18
Al	K	56.60±0.13	43.61±0.10
Total		100.00	100.00

Spc_013 Fitting ratio 0.1028

Graph 27: SEM data showing the are tested had a composition of Al2O3

Advanced gemology also gave mixed results. The FTIR gave strange results that did not have recognizable peaks, so the author did not use it. Raman done with the Horiba evolution had detected corundum with some unusual peaks below 300cm^{-1} (see graph 26). But the SEM gave Al2O3 composition, determining the stone is corundum (see graph 27).

See advanced gemology section under sample 8 for Sapphire Raman spectra study.

Conclusive Remarks

This stone was definitely a tricky one to identify. The tests results were missed and the literature did not cover this sort of treatment closely. While classic gemology was sufficient to determine that the stone was synthetic sapphire and coated, it was not able to tell what the coating was made of. The advanced testing was imperfect too. Most of the devices just showed noise and saturated detectors. The SEM and Raman were the only advanced tests that gave useful results.

Sample #13

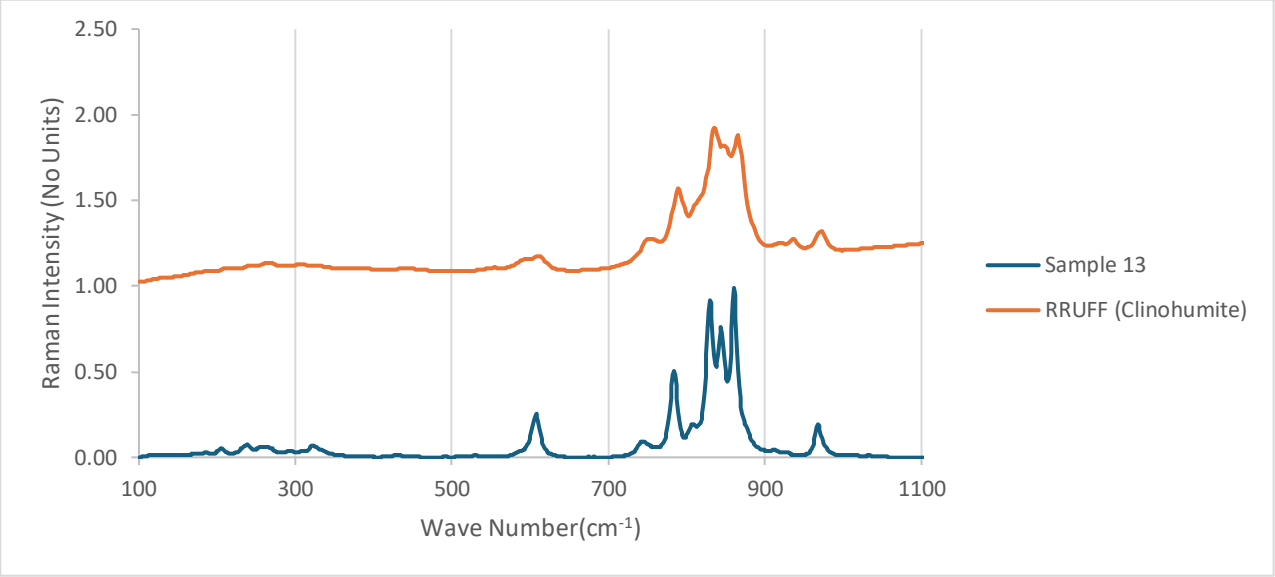
Gemstone	Clinohumite
Sample Name	SPM-JRUS-13(oval)
Weight (ct.)	0.9605
Color	Light Yellowish Orange
Shape/Cut	Faceted Oval
Length (mm)	7.24
Width (mm)	5.47
Depth (mm)	3.70
Mass Volume (g/cm^3)	3.191

Classic Gemology:

Refractive Index	1.638-1.658
Birefringence	0.02
Optic Figure	DR
UV Shortwave	Strong Yellow
UV Longwave	Moderate Orange

This orange stone could be several options including spessartine garnet, but the luster is a little low to be sapphire from just the looks alone. The stone was attractive and had a bright color. The RI was 1.638-1.658 and it was DR. The readings did not match anything in the GIA Lab Manual or the GIA Reference Guide. This combined with the strong UV reaction would definitely be confusing.

Advanced Gemology:



Graph 28: Raman spectra from Renishaw with a power of 10, spectra were acquired in the range 100-1400 cm^{-1}, and over an accumulation of 20 scans. Chart range 100-1100 cm^{-1} for readability. The spectra had great 98% match with RRUFF clinohumite R060559

Advanced Gemology had a great match of peaks with the Renishaw Micro-Raman and had a 98% match with RRUFF clinohumite R060559 from Tajikistan. Using additional literature, it was easy to find a great match (see graph 28). Advanced gemology was possibly the only was to determine the stone's identity without extended knowledge as the basic reference material was lacking.

The most predominant peaks are 831cm^{-1}, 846cm^{-1} and 862cm^{-1} and they are related to V_1 modes of the layered Si-O_4 units. The 607cm^{-1} peak is attributed to V_4 bending modes. The 747cm^{-1} and 784cm^{-1} peaks are ascribed to MgOH and other $M^{2+}OH$ deformations. The observed 970cm^{-1} peak is with in the 870-979cm^{-1} region, which is related to V_3 antisymmetric stretching modes of the SiO_4 unit(Frost et al., 2007).

Conclusive Remarks

Clinohumite can be yellow to brown or white or red colored. It is a 6 Mohs and does not have cleavage. While it is found throughout the world, Tajikistan, Vietnam, and Tanzania are reported to have gemmy material (Bernard & Jaroslav, 2015).

Sample #14

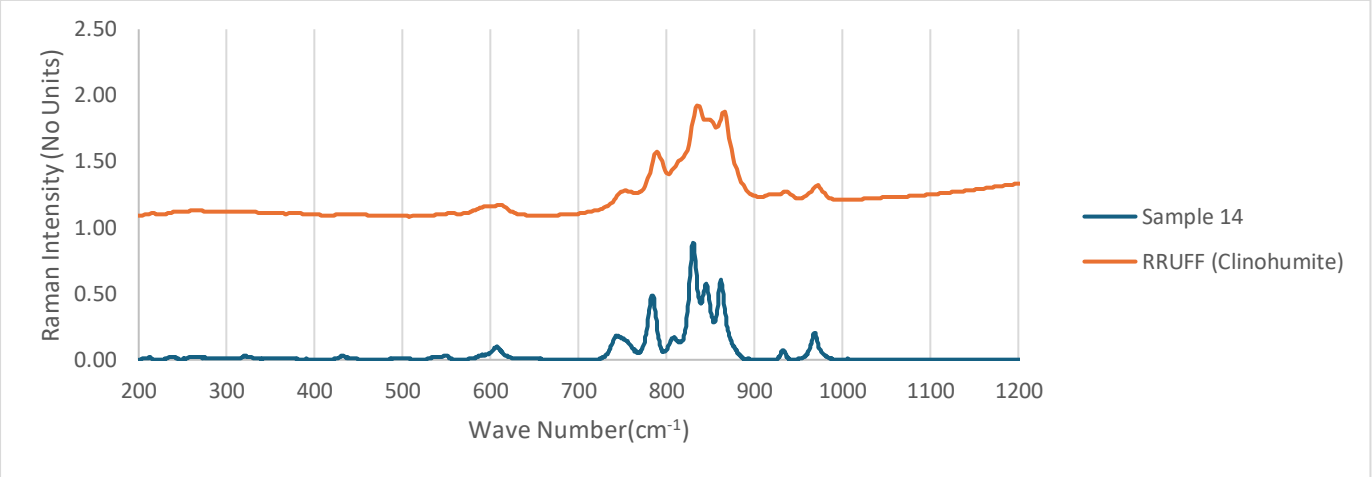
Gemstone	Clinohumite
Sample Name	SPM-JRUS-14(rectangle)
Weight (ct.)	0.6390
Color	Orange
Shape/Cut	Faceted Rectangle
Length (mm)	5.56
Width (mm)	4.54
Depth (mm)	2.95
Mass Volume (g/cm^3)	3.183

Classic Gemology:

Refractive Index	1.648-1.670
Birefringence	0.022
Optic Figure	DR
UV Shortwave	Strong Orange
UV Longwave	Weak Orange

This orange stone would be challenging to sight identify. Spessartine garnet would The RI is 1.648-1.670 and it is DR. GIA's classroom supplied literature doesn't have a good match. The UV reaction further excludes it from the closest options.

Advanced Gemology:



Graph 29: Micro-Raman scattering spectra were measured using a T64000. See Equipment under Materials and Methods section. The spectra were acquired between 200 and 1400 cm^{-1}, with 10 scans of 10 seconds. The T64000 had a 91% match with clinohumite RRUFF R060559 from Tajikistan.

The spectra matched the RRUFF database sample's peaks well (see graph 29). Advance gemology was the only way to identify this stone, outside a great depth of knowledge or a different training institution(GIA).

For Raman spectra study see Advanced Gemology section under Sample 13.

Conclusive Remarks

Advanced testing equipment or an extensive gemology library are essential for determining this stone. This is a challenging stone mainly due to it's rarity and absence in the basic reference guide.

Sample #15

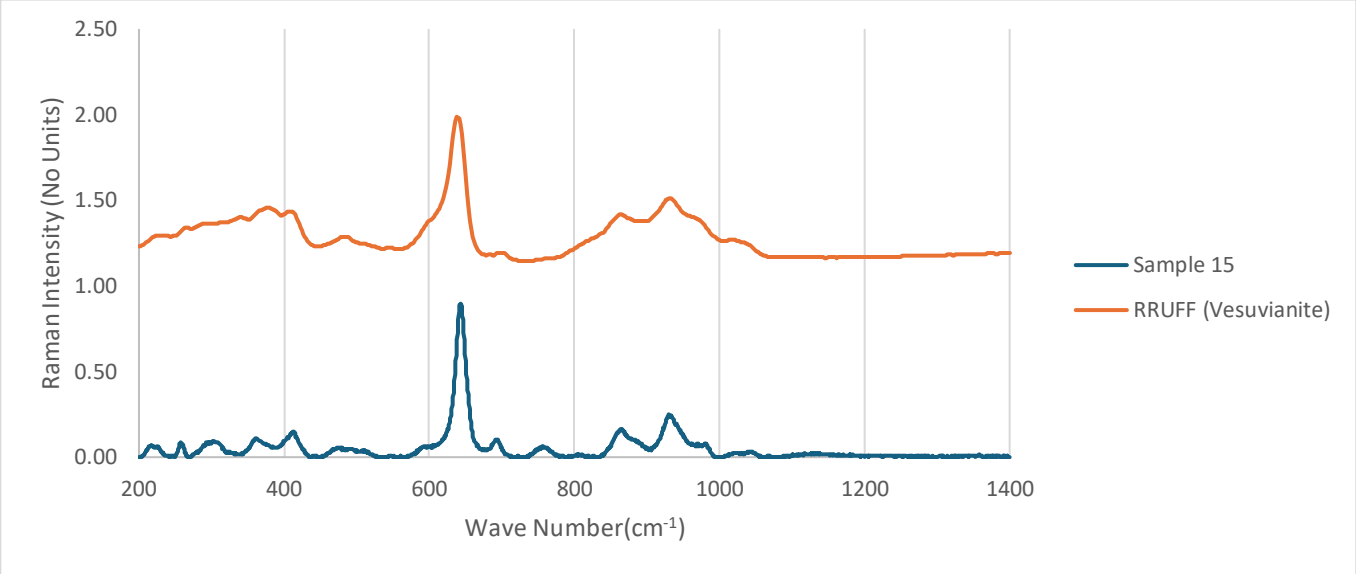
Gemstone	Vesuvianite (Idocrase)
Sample Name	SPM-JRUS-15
Weight (ct.)	1.230
Color	Yellowish Green
Shape/Cut	Faceted Oval
Length (mm)	8.13
Width (mm)	6.04
Depth (mm)	3.30
Mass Volume (g/cm^3)	3.358

Classic Gemology:

Refractive Index	1.712
Birefringence	-
Optic Figure	AGG
UV Shortwave	Inert
UV Longwave	Inert

The yellowish green gemstone could be a variety of things including tourmaline or peridot without doing any tests. The RI is 1.712 and under the polariscope, stays light as the gem rotates (AGG). The best option is idocrase and the RI and optic results are within the description of the GIA Lab Manual. The SG is 3.358 which is within the stated range of 3.40 (+.10/ - .15). Standard gemology was sufficient to identify this gemstone.

Advanced Gemology:



Graph 30: Spectra found using a T64000. See Equipment under Materials and Methods section. The spectra were acquired with 10 scans of 10 seconds. RRUFF database match 91% with sample R050056 vesuvianite.

Advanced testing confirms the classic gemology results. The T64000 Micro-Raman produced a well matching spectra, with many matching peaks. The RRUFF database matched 91% with sample R050056 vesuvianite from Jeffrey Quary, Asbestos, Quebec, Canada (see graph 30).

The collected spectra of the vesuvianite has many low intensity bands with a single main peak at 643$cm^{-1,}$ with the second highest at 930cm^{-1}. Raman can be used to very easily separate vesuvianite from the epidote group. The literature had a second highest intensity peak at 640cm^{-1}, the highest was 930cm^{-1} (Scott et al., 2014). The observed intensity and shift of the wave number can be impacted by the low or high pressure conditions that the vesuvianite formed in (Paluszkiewicz & Żabiński, 2004). Vesuvianite is one of the least understood of the common minerals. There are considerable uncertainties in regard to structure, chemical composition and optic properties (Groat et al., 1994).

Conclusive Remarks

Classic gemology was sufficient to determine the gemstone's identity. But advanced gemology confirmed the identity.

Vesuvianite was part of the idocrase group, now its own vesuvianite group. The gemstone can be blue-green, vivid green, purple, violet, and yellowish brown. The material is 5-6.5 Mohs and poor to missing cleavage. Vesuvianite is found throughout the world (Bernard & Jaroslav, 2015). Vesuvianite's color traditionally was brown to reddish brown, green to greenish brown from Italy (RAH, 1998).

Sample #16

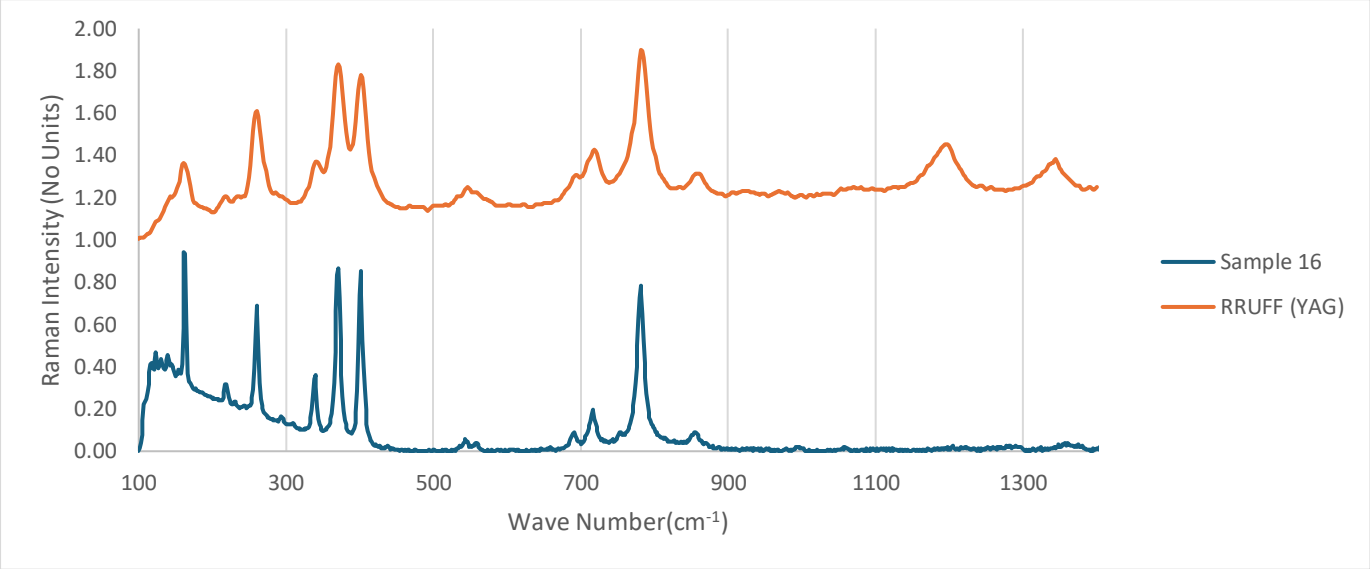
Gemstone	YAG
Sample Name	SPM-JRUS-16(colorless)
Weight (ct.)	2.7795
Color	Colorless
Shape/Cut	Round Brilliant Cut (Round Faceted)
Average Diameter (mm)	8.05
Depth (mm)	5.15
Mass Volume (g/cm^3)	4.566

Classic Gemology:

Refractive Index	OTL (above 1.80+)
Birefringence	-
Optic Figure	SR
UV Shortwave	Weak Yellow
UV Longwave	Moderate White

This Colorless round brilliant cut gemstone appears to be a diamond simulant and potentially CZ without doing any tests. The RI is over the limits (1.80+) of the refractometer. The stone is also SR. This still does not rule out many simulants. The UV reaction and SG of 4.566 confirms YAG with the GIA Lab Manual stating SG of 4.50-4.60.

Advanced Gemology:



Graph 31: Spectra from Renishaw and over an accumulation of 40 scans. The spectra had a 82% match with RRUFF database sample X090003 synthetic yttrium.

Advanced testing with the Renishaw Micro-Raman gave an excellent spectra that matched with the RRUFF database (see graph 31). The spectra from the FTIR and FTRaman had significant noise even on low settings.

The bands at 219cm^{-1}, 263 cm^{-1}, 340 cm^{-1}, 373 cm^{-1}, 402 cm^{-1}, are related to the translatory motion in the Y^{3+} or Nd^{3+} -ions within the distorted cube with eight oxygen ions at the corners, and also the heavy mixing of the rotational, translational, and the V_3 mode of the (AlO_4) unit. The 719cm^{-1} and 784cm^{-1} peaks correspond to asymmetric stretching vibrations in the tetrahedral arrangement (Kostic et al., 2015).

Conclusive Remarks

This stone with enough classic gemology tests was not difficult to identify. If the stone was set and the specific gravity could not be measured it would be significantly more difficult to be certain. The wear at the facet junctions if present might have separated it from CZ. The advanced equipment had some difficulty depending on the device. The FTIR that used a YAG laser required a lot of time to dial in the settings low enough.

Sample #17

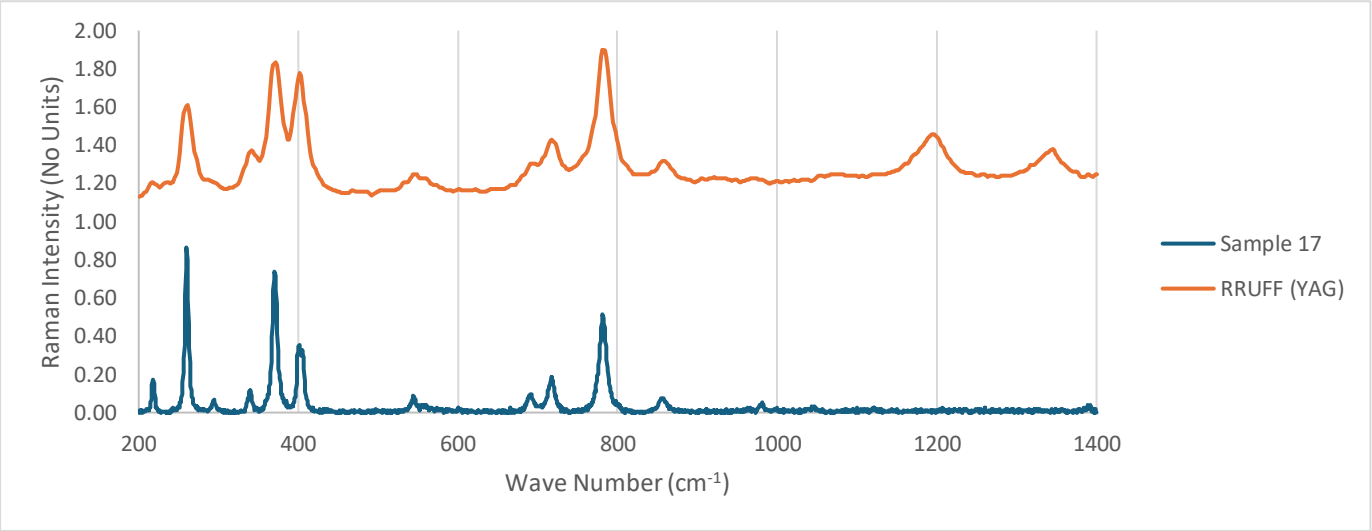
Gemstone	YAG
Sample Name	SPM-JRUS-17(Green)
Weight (ct.)	1.791
Color	Green
Shape/Cut	Round Brilliant Cut (Round Faceted)
Average Diameter (mm)	7.05
Depth (mm)	4.33
Mass Volume (g/cm^3)	4.542

Classic Gemology:

Refractive Index	OTL (above 1.80+)
Birefringence	-
Optic Figure	SR
UV Shortwave	Inert
UV Longwave	Inert

This rich green round brilliant stone appeared to be an emerald simulant like green CZ, YAG or very fine tsavorite. The RI was over the limit and SR. This alone limits it to CZ or YAG. The SG was 4.542, so the only option is YAG. Luckily the stone is loose so the specific gravity can be measured.

Advanced Gemology:



Graph 32: Spectra was measured using the T64000. See Equipment under Materials and Methods section. The spectra were acquired 10 scans of 30 seconds. Overlapped with YAG RRUFF database sample X090003 Synthetic Yttrium 95%.

The T64000 Micro-Raman produced a great spectra with diagnostic peaks. It matched with the RRUFF database sample X090003 Synthetic Yttrium 95% (see graph 32). The Raman was the better option for advanced testing. The FTIR and FTRaman had saturated detectors even on the lowest settings.

For Raman spectra study see Advanced Gemology section under Sample 16. The significant band locations are the same, but several bands had different intensity. The green YAG had higher peaks at 219cm^{-1} and 263cm^{-1}. The colorless YAG had higher peaks at 340cm^{-1} and 402cm^{-1}. The rest of the significant peaks had virtually the same intensity.

Conclusive Remarks

Advanced testing had interesting limitations. The detector was saturated in the FTIR and even on the lowest setting it was never able to produce a usable spectrum. The machine used a YAG laser. The two YAG samples were different colors (green and colorless). The colorless YAG sample on very low settings made a usable spectrum. Perhaps the same colored YAG or similar chemistry was used in the laser.

Synthetic garnet crystal growth was first patented in 1960 and 1962 by James Nielson of Bell Laboratories. Flux growth was achieved first followed by melt growth. Unfortunately, this method did not scale well. To grow material large enough to facet, the platinum crucible would have to be 1.5 gallons and a massive furnace. Czochralski pulling from a melt became the preferred method. Nielsen's 1962 patent proposes applications in gemstones. Both methods can produce gem material. YAG crystals for use in lasers were described in 1964. Smell amounts of neodymium oxide were added and allowed infrared fluorescence and greater output. Late 1960's colorless YAG came into the market as a diamond imitator. Colorless YAG was a more popular stone than the more brittle and softer strontium titanate. Colorless YAG exploded in popularity and peaked in 1972. Over 40 million carats were produced that year, which resulted in a price collapse due to oversupply. In 1977 cubic zirconia entered the market and by 1980 colorless YAG had lost all its market share (Nassau, 1980).

Some would argue that YAG is not a garnet due to not being a silicate. All natural garnets are silicates. Growth of silicate garnets has largely produced glasses, not crystals. So, to combat that, Si has been substituted to achieve growth and avoid glasses. But synthetic "garnets" have the same structure and follow the same general formula. These garnets are considered rare earth garnets and can be doped with scandium, gadolinium or yttrium. By adding transition elements, colors can occur. Green color is achieved by adding chromium. At least one company, Airtron, produced an emerald color imitator. They combined neodymium and chromium (Nassau, 1980).

Discussion:

Number	Stone
1	Hackmanite
2	Lazulite
3	Actinolite in Quartz
4	Petalite
5	Axinite
6	Clinozoisite
7	Sapphire
8	Pargasite
9	Sapphire
10	Muscovite
11	Tourmaline
12	Coated Synthetic Sapphire
13	Clinohumite
14	Clinohumite
15	Vesuvianite
16	YAG
17	YAG

Table 3: The final determination of the gemstone identities.

Conclusion:

All the stones tested have been identified (Table 3). Advanced testing with the support of classic gemology, made testing easy and conclusive. The parcel of Jerry Romanella's unknown stones had a wide array of eclectic varieties and treatments. Some of the stones did not need advanced testing, but stones like the coated synthetic sapphire benefited. The possible identity of the coating would not be possible to determine without advanced testing. The author had hoped for more stones to have difficult to interpret identities. The use of advanced testing devices has ultimately been a great experience. The main limitation of classic gemology was reference literature. Several stones would not be identifiable using GIA's companion guides, as they were omitted. The advanced equipment in general was a powerful tool coupled with RRUFF database and more scientific literature. The Gemmosphere and the MAGI library were severely lacking to misleading in many areas. The Gemmosphere was very good at sapphires and very common stones. The T64000 software was the easiest to use and most cases gave the most consistent and useful data. The Renishaw Micro-Raman was the next easiest to use device and the software was user friendly. The FTIR was very difficult to use at first and the software was challenging. The FTRaman was the second most challenging to use. The use of advanced equipment lets the gemologist go further is analysis.

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Appendix:

All gemstones had the complete standard classical gemology tests conducted on them. All gemstones were tested using the Raman T64000, Raman (Renishaw), FT-Raman, and Gemmosphere. Some gemstones were tested on other devices. Unfortunately, the author did not save the data correctly for many of the tests. The data from the T64000 Raman device is the most complete and therefore the main representation for this project. The results for other devices in general supported the main determination. Other device settings and data collected but not used in this final report. This is due to them either being redundant or incomplete or missing.